Perspectives on Urban Infrastructure

Royce Hanson, *Editor*

Committee on National Urban Policy
Commission on Behavioral and Social Sciences and Education
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Introduction

There is a growing consensus about a nationwide problem with the adequacy and maintenance of the nation's infrastructure, specifically with urban public facilities. There is, however, no consensus on the extent of the problem. Estimates of the backlog of maintenance and repair of bridges, streets, and water and sewer systems range from less than $1 trillion to over $3 trillion. Determining the size of the problem in terms of cost and assessing the proper course for public policy—beyond the obvious actions to repair deteriorated facilities or to replace those in clear danger of collapse—are complicated by the absence of reliable information and confusion over the proper standards to apply. Given the constraints on spending at every level of the political system, people must also decide which facilities should receive the highest priority for investment, since it is reasonably clear that not all claims can be honored in any short time period.

In light of these conditions, the growing demand that something be done, and the likelihood that the "infrastructure problem" will persist as urban areas make further adjustments to a changing economy, changing technology, and changing culture, there is a need to identify the most important and researchable issues and to look for answers to the policy questions of what to do, how much to do, when to do it, and how to do it.

In November 1981 the National Academy of Engineering held a

workshop on urban infrastructure and identified a long list of policy issues for further exploration. In June 1982 a second workshop, held by the Committee on National Urban Policy of the Commission on Behavioral and Social Sciences and Education, the Commission on Engineering and Technical Systems, and the Transportation Research Board, considered the problems of defining needs and setting priorities for urban infrastructure. Participants at that workshop felt that there was a need for an in-depth look at the nation's infrastructure problems and urged the holding of a symposium to develop a specific research agenda for the National Research Council and other interested organizations.

On February 25 and 26, 1983, the National Research Council (NRC) held a Symposium on the Adequacy and Maintenance of Urban Public Facilities. Participants included a cross-section of the academic, political, administrative, and professional leadership of the country in urban public works and civil engineering systems. The objectives of the symposium were to lay out the basis for a research agenda on salient policy issues and to identify and discuss major policy concerns. The program for the symposium and a list of participants appear in the appendixes to this report.

The papers presented at the symposium and the discussion that followed identified an extensive research agenda. Basically, these research needs fall into four categories:

1. the development of standards and criteria for the design and performance of urban public facilities, against which national and local needs for investment can be measured;
2. the identification of the effects of technology on urban infrastructure, including the potential for using new technology to improve the performance and reduce the costs of existing systems and facilities and the need to develop new systems, materials, and devices to support the functions of the private sector in the cities of tomorrow;
3. financing techniques for public facilities systems; and
4. analysis of institutional problems of planning and managing facilities and the processes of decision making.

The symposium was organized to explore public facilities in both historical and institutional contexts. Accordingly, the paper by Joel A. Tarr reviews the relationship between urban development and public works and offers some lessons for current policy. D. Kelly

O'Day and Lance A. Neumann examine the needs issue, pointing out the flaws in facile estimates that obscure the bases on which they are made. George E. Peterson's paper on financing infrastructure explores the usefulness of a national infrastructure bank as a means of encouraging institutional reforms in the way we finance and manage our public works systems. Heywood T. Sanders reexamines the politics of public works decisions and challenges some of the assumptions about the rationality of choices made by cities. Finally, Douglas C. Henton and Steven A. Waldhorn take a look at the future of public works technologies, finances, and institutions.

These papers and the discussions at the symposium provide a point of departure for more searching and comprehensive research on infrastructure needs of the nation and its communities. Their objective is modest: to outline and discuss what is known that is not always taken into account in the making of policy and to identify what is not known but needs to be discovered. In this sense the volume reflects the new interest in the condition of public facilities, a recognition of their importance to the national economy, and the necessity of concern by the scientific and engineering communities for the inner space of our cities as well as for the outer space of the universe.

1

The Evolution of the Urban Infrastructure in the Nineteenth and Twentieth Centuries

Joel A. Tarr

INTRODUCTION

This chapter discusses the origins and development of the urban capital infrastructure in the United States since 1790. Urban infrastructure is defined as the "sinews" of the city: its road, bridge, and transit networks; its water and sewer lines and waste disposal facilities; its power systems; its public buildings; and its parks and recreation areas.[1] In developing an analysis, the chapter draws on history in three ways: to furnish perspectives on the evolution of the urban infrastructure over time; to point to critical stages, paradigm shifts, and key turning points in history; and to provide analogies between the contemporary so-called crisis of the infrastructure and similar events in the past (see Stearns and Tarr, 1982). The chapter is structured around questions concerning the demand for public works; the factors affecting their supply; the character of the provider (public, public-private, or private); and the relationship of urban infrastructure to financial, political, technological, spatial, public health, social, and demographic considerations.

[1] There is no comprehensive study of the history of the urban infrastructure, although Armstrong et al. (1976) supply much of the important background. For an annotated bibliography of works in the field, see Hoy and Robinson (1982); see also Mochring (1982) and Aldrich (1980). Throughout the paper, the terms urban public works and capital infrastructure are used interchangeably.

The model of the city used in this chapter views cities and urbanization as arising from the interaction of technology and society. Cities develop because technology, in coordination with other social, cultural, political, and economic factors, makes possible the production of surpluses. Surpluses were primarily of two kinds: agricultural products that permitted survival in an urban environment and manufactured goods produced in the city for local consumption and for export. In addition, cities also supplied services, and these often depended on technologies of different forms. Over time, city growth and the evolution of urbanized areas were closely related to a process of technological innovation and implementation that produced strong multiplier effects throughout the society. Hence, in the United States and Western Europe, a predominantly agricultural society was replaced in the nineteenth century by an urban industrial society, which in turn has been recently succeeded by a postindustrial society more dependent on technology, communications, and specialized knowledge than at any time in the past (Berry, 1981).

Capital infrastructure played a vital role in these major societal changes. Economic development and urbanization could not have occurred without infrastructure creation (Aldrich, 1980; Dunn, 1980; Pred, 1966:13-85). A rigid technological determinism or a simplistic demand model, however, distorts the pattern of the evolution of infrastructure. While infrastructure construction patterns do relate closely to swings in the development process and to city building cycles, government has also used public works for countercyclical, employment, and political patronage purposes. The preferences and perceptions of different actors such as business leaders, politicians, and professionals in a particular city at a particular time may be more important in the city building process than a generalized set of forces that relate to all cities.[2]

For purposes of analysis, this chapter uses four historical stages of infrastructure development related to the process of urban change:[3]

- Urban Networks and Walking Cities: A Period of Foundations, 1790-1855

[2] Cases illustrating the important role of individuals in shaping public works decisions are presented in Caro (1974) and Kahrl (1982).

[3] The rationale for the periodization is as follows: 1855 is the date of the construction of the first sewerage system (Brooklyn); 1910 marks (approximately) the beginning of the automobile era; and 1956 is the date of the passage of the Interstate Highway Act.

- Constructing the Core Infrastructure in the Central Cities, 1855-1910
- The Domination of the Automobile and the Enlargement of the Federal Role, 1910-1956
- The Rise of the Outer City and Recent Trends Influencing Urban Infrastructure, 1956-1982

History, of course, does not fall into neat compartments. Any scheme of this type risks oversimplification, for there were often important lags in different sectors with regard to adoption of new technology. This is especially true of infrastructure. Its elements have often been extremely slow to change, imposing restraints on the freedom with which economic forces or public policy can reshape the city (Martin and Willeke, 1978:29-58). Infrastructure has thus served both as a force for development in one period and as a barrier to change in another.

URBAN NETWORKS AND WALKING CITIES: A PERIOD OF FOUNDATIONS, 1790-1855

During the years from 1790 to 1860, the urban population of the United States grew from approximately 202,000 to over 6 million. In 1790 there were no cities with a population of more than 50,000; in 1860 there were six, with two having a population of over 500,000 and one over 1 million (Bureau of the Census, 1975:Pt. 1, 11-12). The first cities were sited on good port locations along the Atlantic Coast, providing key linkages for the transshipment of raw materials from the continental interior to Europe. These cities were primarily commercial and break-of-bulk locations that developed substantial manufacturing functions only in midcentury. The initial urban network consisted of a line of Atlantic Coast cities, but by the 1820s a second urban frontier of interior cities had developed along inland waterways, such as the Ohio and Mississippi rivers and the Great Lakes. This latter network largely focused on internal rather than external markets. In several of these interior cities, such as Cincinnati and Pittsburgh, local industries developed to take advantage of strategic location, access to raw materials, and nearby markets. In addition, a number of more specialized industrial mill towns grew along water power sites in the New England and Middle Atlantic regions (Pred, 1966:143-196).

To a large extent, cities during this period were walking cities. That is, even the largest cities had relatively compact spatial areas,

dense population and land use densities, mixed patterns of land use, and no large separation, if at all, between workplaces and residences. Usually the means of public transportation were minimal. Horse-drawn buses called omnibuses appeared in a few cities, such as Philadelphia and Baltimore, in the 1820s and 1830s; commuter railroads first carried passengers in Boston in the 1830s; and the street railway, with horses as the means of motive power, received its initial systematic development in New York in 1852. Only a relatively small number of urban inhabitants, however, utilized these relatively expensive and often slow forms of transport (Taylor, 1966:Summer, 35-50; Autumn, 31-54).

Government on many levels—federal, state, county, and city—constructed parts of the infrastructure in this period, stimulating urbanization and economic development. Federal efforts were relatively minor compared with those of states and cities, with the federal government financing the construction of roads, lighthouses, and river and harbor improvements and supporting canal and railroad projects through land grants, stock subscriptions, and federal subsidies. One author has estimated that total federal expenditures on internal improvements from 1820 to 1840, not counting subsidies to state and private projects, probably amounted to about 11 percent of the federal budget (Aldrich, 1980:F.8).

The most innovative policies with regard to infrastructure development took place on the state level. State aid to public works projects increased after the opening of the Erie Canal in 1825, stimulated by trade competition between states and cities and necessitated by private capital shortages. Economic historians have calculated that of the total investment of $188 million in canal construction in six states between 1815 and 1860, approximately 73 percent was financed by state and municipal governments (Bruchey, 1965:128-133). Most of the sum was raised by the sale of bonds to investors, a high proportion of whom were foreign. The aim of the investment was to use transportation improvements such as canals, roads, and railroads in a developmental mode: to escape the tyranny of topography, to form efficient links between the various urban nodes and regions for the movement of goods and people, and to provide for penetration of the fertile western territories. Many of these projects were directed by private-public "mixed" boards, with government acting as "planner, promoter, investor, and regulator" (Lively, 1955:81-95). Faced by the need for development, state government thus acted to reduce risk, provide investment, and supply an institutional structure for further private activity.

State investment in transportation infrastructure contra ted sharply after the depression of 1837, with a second wave of on- traction after the depression of 1857. State constitutional res ric- tions passed after the depressions forced many states to a pa; as- you-go basis and to severely restrict new projects.

Municipalities and counties, however, convinced that they ere doomed economically without access to a railroad line or a ca ial, filled the infrastructure investment gap. State legislatures pa sed hundreds of laws permitting the granting of local aid. In 1 43, municipal debt was approximately $27.5 million and federal and state debt $231 million (Figure 1-1). By 1860, however, muni pal debt had reached over $200 million, almost as large as state ebt (Hillhouse, 1936:32-34). Cities such as Baltimore, Cincinnati, Mil- waukee, and Pittsburgh bought railroad stock, purchased rail oad bonds, guaranteed the credit of railway companies, and even r ade outright gifts. By the 1850s, however, many cities were dis llu- sioned with the policies of the railroads and questioned the wis om of public subscription to railroad corporation stocks and bonds. on-

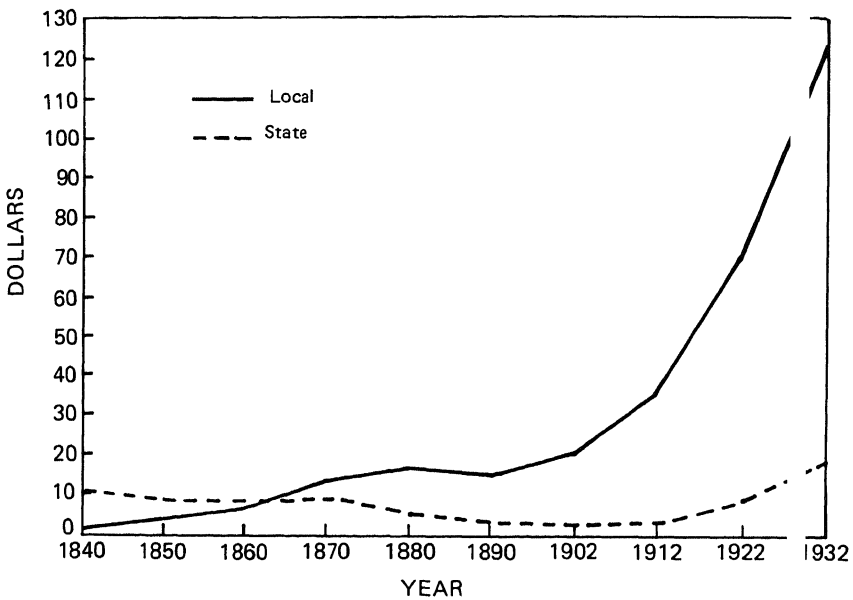

FIGURE 1-1 Per capita state and municipal debt, 1840-1932. SOURCE: Based o data from A. M. Hillhouse, 1936, *Municipal Bonds: A Century of Experience*. New York: Prentice-Hall.

troversy over the relationship between tax revenues and financial obligations to railroad bonds created political conflict in cities such as Pittsburgh and Milwaukee in the 1850s and 1860s (Booth, 1983:335-363; Holt, 1969:220-262; Olson, 1980:156-160). In the post-Civil War period, amidst a severe financial downturn, municipalities widely rejected the policy of financial subsidies to private corporations.

The Development of Urban Infrastructure

While states, counties, and municipalities provided capital for the construction of intercity and regional transportation infrastructure, city governments also began to assume many of the service functions that are currently accepted as their chief responsibility. This was a shift from the earlier pattern. While eighteenth-century municipalities provided some infrastructure, such as street paving and lighting, town wells, and docks, their chief concern was with the regulation and protection of commercial activities. In addition, many services that later became a municipal responsibility were handled by volunteer groups or were an individual responsibility (Goldfield and Brownell, 1979:83-86; Lane, 1967:6-8; Teaford, 1975). These patterns changed gradually in the nineteenth century. By the 1840s and 1850s, in the larger municipalities, functions such as fire fighting had become the responsibility of professional fire departments; organized police forces had taken the place of the night watch and constables; and urban governments had enlarged their activities in matters involving public health and sanitation (Goldfield and Brownell, 1979:170-180). Diffusion of the more modern governmental forms through the urban network, however, took place at a relatively slow pace, with the older and larger cities making innovations first.

Structural changes in city government permitted the development of the service orientation, as states granted municipalities new charters and authorized the revision of old ones. A democratic revolution that erased property qualifications for voting permitted citizens to elect mayors and specialized officials instead of having city councils appoint them. In many cities bicameral legislative bodies and ward systems replaced unicameral councils chosen in at-large elections. Governmental control in the larger cities began to shift from the hands of a commercial/propertied leadership to a new group of professional politicians who relied on appeals to the

urban masses for election (Gluck and Meister, 1979:43-46). In the smaller and medium-sized cities, however, such as Houston, Texas and Springfield, Massachusetts, the commercial/propertied groups continued to dominate until close to the end of the century (Frisch 1972:241-246; Platt, 1983:96-103).

Accompanying the political changes were governmental alterations that related directly to the management of public works. Many cities, for instance, introduced standing committees on their councils rather than operating out of the council as a whole. Pittsburgh, for example, had nine standing committees in 1828 concerned with finance, water, streets, paving, claims and accounts, assessments, wooden buildings, canals, and wharves and public lands (Wade, 1959:273). City council committees, however, often could not provide the uniform procedures required by growing infrastructure construction. The solution was to create additional executive departments, a move often resisted by city aldermen. New York City, for instance, in the 1830s had a desperate need for more executive departments, but the Common Council refused to respond, even though the 1830 city charter called for their creation. The councilmen preferred to keep power over public works in their hands rather than making them an executive responsibility (Moehring, 1981:55-56).

The forces underlying the changes in city government, especially increased infrastructure construction, were more complex than simple economic models suggest. It is always hazardous to generalize about the causation of large-scale change, especially in a situation involving a host of cities ranging in size and location, but some tentative observations are possible. First, it is clear that much infrastructure construction and municipal delivery of urban services was related to commerce and development (Goldfield and Brownell, 1979:168-170; Moehring, 1981). In this regard, government was serving the same role as it did in providing support for internal improvements; that is, it acted to aid the private economy, especially business interests and real estate developers. Second, a set of forces driving change stemmed from considerations that related not only to development but also to concerns about the public order and the public health (i.e., preventing the spread of epidemic disease). The actors who reflected this set of views included a number of commercial elites, professionals, and sanitarians (Warner, 1968:99-160). Third, the 1840s and 1850s saw the rise of a new type of urban political professional who based his career on appeals to the recently

enlarged electorate. In this context, the delivery of public works improvements and of services was often a response to voting constituencies or the needs of specific interest groups (Gluck and Meister, 1979:45-52).

The interaction of the various forces driving infrastructure construction is clearly illustrated with regard to three areas of importance in the walking city: streets, water supply, and sewers.

Because they were sensitive to the constituencies interested in the streets, city council members considered questions involving streets approximately half to two-thirds of their time. These debates revolved around matters of financing, the timing of openings, and whether private companies or the public authorities would do the most effective job of street cleaning and maintenance (Goldfield and Brownell, 1979:170-171).

Generally, city councils responded quickly to requests for street openings or improvements that served commerce and related to the flow of business in and out of town and in the principal business section. Downtown streets were usually paved first, while most secondary streets were unpaved. Cobblestone had been utilized extensively for paving since colonial days, but was generally unsatisfactory because it resulted in noise, collected filth, and broke under heavy traffic. In the 1830s, cities began searching for smoother pavements and experimented with wood, stone blocks, bricks, and planks. It was not until the chemical and technological advances of the late nineteenth century that more satisfactory improved asphalt and concrete materials became widely available (Armstrong et al., 1976:66-67; McShane, 1979:279-281).

Residential neighborhoods had different requirements. Abutters decided when and how streets would be paved by petitioning the municipal government. Normally, whenever residents holding two-thirds of the front footage on a block petitioned the council, the municipality would arrange for paving and collect special assessments from all abutters. If assessments were not fully paid, costs had to be covered by the general tax fund (McShane, 1979:284). Not surprisingly, paving was more common in wealthy neighborhoods and less common in the poorer areas. Since the city government was responsible for maintenance, residents often preferred cheaper forms of paving. Gravel (macadam) was most widely used, followed by cobblestone. According to historian Clay McShane, the limited amount of paving in residential areas reflected not only citizen reluctance to assume the financial costs but also a desire to protect

the social functions of streets, common in the walking city, fror disruptive traffic (McShane, 1979:285-290). Changes in values a well as technology in the late nineteenth and early twentieth cen turies altered these preferences.

Once constructed, streets required maintenance and cleaning i they were to serve as proper circulatory mechanisms for commerce people, and the removal of wastes. These functions were largely a municipal responsibility, and their proper delivery was contingen on funding availability and adequate administrative procedures. Ir a period of municipal change, the result was a seesaw between the demand for service and the demand for economy and between the private contract system and the municipal scavenging corps. In small cities especially, fiscally conservative governments resisted the public assumption of service responsibilities longer than did large cities. In all communities, however, the normal pattern was clear—priorities were largely determined by commercial needs, by wealth, and by status. Few streets in the cities of this period, however, were ever clear of horse manure and other forms of filth.

Street networks served not only for the supply and circulation of the various goods required for urban life but also played an important role with regard to other vital elements of the city's metabolism—the supply of water and the removal of human wastes, contaminated water, and garbage. Theoretically, all these materials could be transported to places of disposal along street surfaces, but only at very high financial and nuisance costs. The two most critical elements relating to the urban metabolism were water supply and human waste removal. It was in these two areas that the greatest technological advances—both using the subsurface rather than the surface of streets—were made during the period of the walking city.

Water came first. Until the last quarter of the nineteenth century, most American urbanites depended on local sources for water supply. Householders usually dug their own private wells or used water from neighborhood ponds, streams, and springs. In cities such as New Orleans, where poor groundwater quality restricted the use of wells, cisterns caught and preserved rainwater. Vendors also carried casks of water from private streams and peddled water on the streets. As early as the eighteenth century, there were both private and public water suppliers. In Philadelphia, for instance, entrepreneurs who built wells on public property to sell water to the public paid a rental fee for the site. In the mid-1750s, the city purchased private pumps and assessed nearby residents for their

use; by 1771, Philadelphia owned 120 of a town total of 498 pumps. In New York City in the late 1780s and 1790s, the town encouraged new well construction with subsidies and provided funds for repair, cleaning, and construction from a statewide tax (Blake, 1956:3-17).

In spite of municipal involvement, local supplies were inadequate to provide for the needs of growing cities. Wells and ponds became visibly polluted and groundwater levels receded. The desire of urbanites for more copious and cleaner water supplies, concern over threats to the public health from polluted local sources and inadequate water to flush filthy streets, and the insufficiency of water supplies to control the fires that frequently raged through antebellum cities led to a search for nonlocal sources of supply. As cities became more industrialized, industrialists joined to demand a pure and abundant supply of water for their various processes (Moehring, 1981:32-37). Water supply, therefore, represents a situation in which a number of interests—business and industries, homeowners, fire insurance companies, and those concerned with the public health—joined to demand the construction of large public works in order to secure more adequate supplies. City boosters considered waterworks as crucial in the competition between municipalities for population, trade, and industry and emphasized their possession in touting their cities.

The first large city to construct a municipal water supply system was Philadelphia, which acted in 1798 because of a yellow fever epidemic. Cincinnati installed a water system in the 1820s, New York opened the Croton Aqueduct in 1841, and Boston the Cochituate Aqueduct in 1848. By 1860, the nation's 16 largest cities had waterworks, with a total of 136 systems—57 public, 79 private (Armstrong et al., 1976:217-222). The larger cities were more likely to have publicly owned waterworks and the smaller cities to have privately owned, many with relatively few users. The large capital requirements of the systems and frequent inadequacies of the private companies necessitated public ownership. Cities that began with private water supply companies, such as New York and Chicago, shifted to public ownership because the private companies refused to provide adequate water for civic purposes such as street flushing and fire hydrants, to eliminate pollution, to enlarge their works in anticipation of population growth, or to service distant districts (Anderson, 1980:119-124; Galishoff, 1980:36). In some large cities, however, such as Denver and Kansas City, water systems remained private until the twentieth century.

The provision of water supply, therefore, especially in large cities, presents a triumph of technology and administration in the construction of large public works for a needed service. A capital-intensive and centralized technological system replaced a decentralized and labor-intensive method of delivery. Progress, however, was far from uniform, and municipalities encountered many problems in the process of development and construction. In Baltimore and New York, for example, vested interests in the existing privately owned systems and the high costs of purchase caused city councils to resist assuming the water supply functions for a number of years (Moehring, 1981:23-32; Olson, 1980:81). In addition to these delays, city councils debated endlessly over property rights and the recommendations of various engineering reports before they could agree on the source of water or the character and technology of the distribution system. Cities often functioned with inadequate supplies at a high cost in fire damage and disease long after the technological capability for improved water systems existed (Blake, 1956:100-247).

Other difficulties arose from the uneven distribution of water supplies. In cities with private companies, such as Baltimore until 1854, water supply was class structured. The affluent residential districts and the central business district received the piped water of a private corporation for an annual fee, while the working class districts continued to depend on shallow polluted wells supplied by city pumps (Olson, 1980:132-133). In New York City, after construction of the Croton Aqueduct, the picture was more varied, and all of the city's lower wards, rich and poor, American and foreign, enjoyed Croton water. City councilmen responded to petitions from residents unable to afford household connections by providing hundreds of free hydrants. In uptown Mahattan, however, the mains only extended to clusters of middle-class or upper-class homes. According to the leading historian of nineteenth-century New York public works, a range of elements, including economic, class, and political factors, as well as the influence of the real estate developers, affected the distribution of water mains (Moehring, 1981:37-51).

Until 1860, water systems diffused through the urban network at a relatively slow rate. This pattern suggests that local supplies remained adequate for most needs in small- and medium-sized cities, making private entrepreneurs reluctant to invest; that information and skills concerning waterworks technology were rela-

tively scarce commodities; and that municipalities would not or could not secure the capital necessary for these large public works. In cities with well-developed systems, like Boston, Chicago, and New York, individual consumption usually increased at a rapid rate (Anderson, 1980:86-125). Consumption figures must be regarded with caution, however. An absence of meters, the use of annual flat charges, and the presence of free hydrants as well as technological factors such as leaky pipes, faulty pumps, and bad connections, led to tremendous waste. Although urbanites would clearly consume more water if it was available at a reasonable price, many city dwellers continued to depend on wells for their water supplies throughout the nineteenth century.

A supply of potable water was only part of the city's metabolic system. Human wastes and used water, as well as solid wastes, also had to be disposed of. Ideally, they should have been removed from the settled areas, but, in most locales in this period, human wastes and wastewater were disposed of in cesspools and privy vaults located close by residences or even in cellars. When these receptacles were full, they were covered over with dirt and new ones dug. By the 1820s and 1830s, most large cities tried to institute periodic vault emptying by private scavengers under city contract or by city employees, but again the experience was similar to that of street cleaning—dissatisfaction with performance under whatever system was in effect and a seesaw between service by municipal employees and the private contract system (Tarr and McMichael, 1977:166-167).

While both private and public underground sewers existed in the larger cities such as New York, Baltimore, and Boston, they were intended for stormwater drainage from streets rather than for human waste removal. The majority of nineteenth-century cities, however, had no underground drains. Street gutters of wood or stone, either on the side or in the middle of the roadway, provided for stormwater and occasionally for human wastes. Private householders often constructed drains to the street gutter to remove rainwater from cellars. Municipal governments focused on the removal of stormwater from streets because of the need to keep roadways clean for commerce, the problems of flooded basements, and the belief that standing water gave rise to "miasmas" that endangered the public health.

The cesspool/privy vault method of human waste and wastewater disposal had certain characteristics that sharply differentiated it

from the system that replaced it. Maintenance of the waste disposal sites was primarily an individual responsibility; waste removal was labor- rather than capital-intensive; and, even though many municipalities had ordinances requiring the periodic cleaning of privies, the regulations were not enforced on a regular basis, but only when overflows created a nuisance or when an epidemic threatened.

A combination of demographic and technolgical factors combined to overload the cesspool/privy vault system and to cause its eventual collapse and replacement. City population growth also gave rise to higher densities, especially in the original central cores. Transportation limitations restricted the distance that population growth could spread from places of employment and essential urban institutions. With the growth of urban densities and an explosion of building construction, the existing land-intensive waste collection system became increasingly inadequate. Overflowing privies and cesspools filled alleys and yards with stagnant water and fecal wastes, and wells in close proximity to the overloaded waste receptacles became badly polluted (Tarr et al., 1980:59-64).

Construction of water systems in cities increased the stress placed by population growth on the cesspool/privy vault system. The availability of a constant unmetered source of water in households and in hydrants caused a rapid expansion in usage, as demand interacted with supply. Households installed a range of water-using appliances and ran the used water into existing cesspools because of a lack of sewers for household water wastes. The most serious problems were caused by the water closet. In cities with waterworks, affluent families installed closets to take advantage of their convenient in-house location and comparative cleanliness. The capacities of their cesspools were quickly overwhelmed; yards and alleys were overrun with fecally polluted wastewater. Householders were offended by the nuisance, and physicians and sanitarians who believed that disease was caused by miasmas generated by filth and decaying organic matter ("anti-contagionists") were concerned about possible epidemics (Tarr et al., 1980:61-64).

The adoption of new technologies, therefore, combined with higher urban densities to cause the breakdown of the cesspool/privy vault system of waste disposal and the generation of excessive nuisances. Different solutions were tried, but eventually most sanitarians, engineers, and business leaders agreed that the water carriage technology of waste removal was the most effective one available. This

technology had the advantage of solving the problems of collection and transportation simultaneously. A number of private sewers had been built in cities to serve single streets or groups of houses, but it was not until the 1850s that the first planned municipal systems were constructed (Peterson, 1979:84-89). Municipalities made the decision to build these capital-intensive elements of the infrastructure only after extensive debate about technological alternatives, the validity of different hypotheses of disease etiology, and the possibility of modifying existing systems of stormwater sewers to carry household wastes (Tarr, 1979:308-313).

The construction of the initial sewerage systems signified a movement away from the "piecemeal, decentralized approach of city-building characteristic of the 19th century" (Peterson, 1979:84-89). This unplanned approach was illustrated by the New York sewer system before 1860. Most New York sewers had originally been built for rainwater drainage, although from 1845 on the city councils permitted connections with household drains. Some sewers were circular, while others were elliptical; some were constructed of stone and others of brick. A number of streets had private sewers that made their own path to the river. A lack of maps or records prevented maintenance, even if municipal authorities had been so inclined (Moehring, 1981:87-95). Thus, adoption of planned sewerage systems substituted a systematic, sanitary, and self-acting technological system for a haphazard, inefficient, and unhealthful manner of dealing with human wastes, wastewater, and stormwater disposal. Beginning in the 1850s, therefore, planned sewerage systems became part of the infrastructure of urban America, although it was not until the last decades of the century that the great wave of municipal sewer building took place.

Financing Infrastructure in the Walking City

Large-scale municipal involvement in the construction of urban infrastructure, such as streets or capital-intensive water supply and sewerage systems, required a resort to new forms of financial instruments. Projects such as street improvements were often financed by assessments on abutters because of a municipal reluctance to become involved in debt. When abutters did not or would not pay, recourse to general tax revenues was necessary. During the 1800-1860 period, property tax rates more than doubled (Hillhouse, 1936:36).

Many capital-intensive infrastructure projects, such as street

lighting, schools, water and sewer systems, and various public buildings, were financed with municipal bonds; city tax revenues were usually insufficient to cover capital costs. Large-scale debt financing was new to American cities. When the building of the Croton Aqueduct increased New York City's debt from $500,000 to over $9 million, many citizens anticipated financial disaster (Studenski and Krooss, 1952:134). Municipal infrastructure creation plus involvement in various railroad funding schemes increased municipal debt from $27 million in 1843 to $200 million in 1860. At the same time, operating expenses for debt service and for functions such as police and fire protection, education, and street maintenance also rose rapidly. From 1800 to 1860, total municipal per capita expenditures rose from about $2 to $12 in current dollars (Hillhouse, 1936:36) (see Figure 1-1).

Engineers and Urban Technology

While it is customary today to assume that the construction and maintenance of urban infrastructure involves the talents of trained engineers, this was not necessarily true with regard to the period from 1790 through the 1850s. There were a limited number of persons who identified themselves as engineers in the United States in the first decades of the century; one historian has identified about 30 individuals in 1816 who were active or available as "something like engineers" (Calhoun, 1960:22). One of the few traits they had in common was their involvement with public works. The group included men who were surveyors, contractors, builders, and lawyers. Some were trained in Europe; others had been educated in the few American institutions that offered engineering education, while many had secured on-the-job training.

Economic historian Nathan Rosenberg has observed that technological change in nineteenth-century America depended on the borrowing of the major components—machinery, power, and new materials—from a stock of innovations that had already been developed and employed in Great Britain (Rosenberg, 1972:59-86). The basic factor behind the transfer process and its internal diffusion was economic. Rosenberg further comments that transfer and diffusion were selective, based on an economic calculation of profitability in the new environment. Technology transfer was vital to the construction of the nineteenth-century urban infrastructure. According to one student of nineteenth-century American technol-

ogy, the basic agents of technology transfer in the antebellum period were individuals—Europeans who learned the technology abroad and carried the knowledge to the United States and Americans who went to Europe to learn about technology (Genson, 1975:7). Both exchange processes were at work with regard to the transfer of urban technology.

Benjamin Henry Latrobe is often pointed to as the prime example of a trained European who brought his skills and knowledge about advanced English technology to the United States. Latrobe was trained in England and Germany, acquiring a classical education and knowledge of mathematics and science as well as studying and working with famous British architects and engineers. He constructed a number of urban public works, including the Philadelphia Waterworks (1799-1801), a drainage system for Washington, D.C. (1815-1816), public buildings including the United States Capitol and the President's house, and parks and educational facilities (Carter, 1976:14). Perhaps Latrobe's most outstanding technological enterprise was the Philadelphia Waterworks. This project required heavy capital investment for its two steam engines and its basins, canals, tunnels, and distribution system. The most advanced engineering project of its time, it attracted national attention and "created technological momentum" in waterworks construction (Carter, 1975:24).

While there were other European-trained engineers who made substantial contributions in America, the supply of engineers was increasingly homegrown. Many American civil engineers secured their training on the great state public works endeavors of the period, such as the Erie Canal, the Pennsylvania Main Line Canal, and the numerous railroad projects. In addition to the practically trained engineers, West Point and engineering schools such as Rensselaer Polytechnic Institute and Stevens Institute produced a growing contingent of graduates. Engineers worked as directors of large internal works projects (engineer-managers), as contracting engineers, and as consulting engineers, especially in situations in which local talent was inferior. By the 1840s, civil engineers formed a definite occupational group (Calhoun, 1960:182).

Many of these engineers moved freely between the large state public works projects and the major urban infrastructure developments. John B. Jervis, for example, secured his engineering training in eight years of work on the Erie Canal as an axeman, rodman, stone-weigher, and surveyor. He later served as chief engineer of

New York's Croton and Boston's Cochituate aqueducts. Ellis S. Chesbrough was trained on the transportation projects of the 18:)s and 1830s, then worked with John B. Jervis on the Boston Wa er Works in the 1840s. Chesbrough became the first Boston city n- gineer in 1851, then chief engineer of the Chicago Sewage Cc n- mission in 1855. Julius W. Adams, who studied at West Poi t, gained extensive experience on various railroad projects bef e planning the Brooklyn Sewerage System in 1857 (American Soci y of Civil Engineers, 1972; Calhoun, 1960:47-53).

Engineers such as Adams, Chesbrough, and Jervis drew on E n- ropean concepts but modified them to fit American conditions. n- creasingly, as Rosenberg notes, American engineers acted as i i- tiators in technological innovation, rather than as borrowers. Ma y basic developments came in areas in which the nation was rich – farm machinery and woodworking machinery, for example (Rose n- berg, 1972:87-116). For cities in these years a critical developme nt was the streetcar, initially powered by horses and later by cal e and electricity. This innovation first appeared in New York C y in 1852, and fixed rail systems became a vital part of the urb n infrastructure in many cities. Streetcars became the instrument r a radical change in urban spatial patterns, and the subseque nt urban growth generated a huge demand for other forms of inf n- structure, such as streets, water systems, and sewers (Ward, 1971:1:)- 146; Warner, 1962).

In addition to streetcars, other important native innovations e- curred in building and construction methods and materials (e. ., the balloon frame and cast iron framing); wooden and iron tru s bridges; and wire cables for bridges and inclines. The telegraph w s an important American invention that was adapted to urban serv e delivery systems; municipalities widely adopted it beginning in t e 1850s for fire and police alarm systems. These developments co n- bined with other European and British imports, such as street pa r- ing, gas lighting, sewers, and omnibuses, to make the technolo y of the American urban infrastructure a blend of European ide s and adaptations and homegrown inventions and innovations (Ar n- strong et al., 1976; Merritt, 1969).

Conclusion

The critical infrastructure developments that occurred duri g this period of foundations were two: the construction of a tra n-

portation network connecting the various urban nodes primarily through state investment and the assumption by municipal government of a responsibility for various service functions. Driving these changes was a thrust toward economic development, a concern for the public safety and the public order, and a new responsiveness on the part of the political structure to the demands of various groups in the urban population. Facilitating the changes were experiments on the state level with private-public partnerships, changes in the structure of urban government, a willingness on the part of municipalities to assume debt obligations in order to provide infrastructure, and an increase in the supply of trained civil engineers capable of constructing and operating urban technologies.

In the larger cities such as Boston, New York, Chicago, and Philadelphia, these new patterns produced a movement away from a piecemeal, decentralized approach to urban infrastructure to one characterized by system, planning, and expertise. These changes, however, even in the larger cities, occurred slowly. It would take a number of decades before the advances made in the largest urban centers would spread throughout the urban network.

CONSTRUCTING THE CORE INFRASTRUCTURE IN THE CENTRAL CITIES, 1855-1910

Introduction

The period between the 1850s and 1910 was one of continued rapid city growth due to natural increase, farm-to-city movement, and foreign immigration. Urban population increased from about 6 million in 1860 to 25 million in 1900, then to 42 million in 1910. By the latter date, approximately 46 percent of the nation's population was living in urban areas, and large cities (of more than 100,000 population) had become relatively numerous. The urban network, which had been largely confined to the area east of the Mississippi River in 1860, extended from coast to coast by 1910, with the nodes connected by railroad, telegraph, and telephone lines. While all regions experienced increased urbanization, the proportionate share of urbanized population shifted, with the North Central region and the West increasing their share, while the Northeast declined (Ward, 1971:11-50).

Cities grew in area as well as in population. Transportation innovation facilitated the process of urbanization and the growth of

metropolitan aggregates characterized by central cities surrounde by contiguous suburbs. Cities grew spatially by annexing territo as well as by population spread. Spatial expansion resulted in a tered population densities, with high peripheral growth rates a parent for many municipalities as early as 1850 (Jackson, 1975:11 142). The process of deconcentration caused the gradual replac ment of the compact and congested walking city with cities th had lower densities spread over larger distances.

Infrastructure was critical in this process of urban change. D velopments in infrastructure fall into two periods during this spa of years: the 1850s through the 1880s, and the 1890s through a proximately 1910. The first period was marked by a continuatic of the movement from a piecemeal and fragmented provision infrastructure to more of an emphasis on centralized systems, whi the second witnessed the most sustained thrust toward infrastru ture provision in the nation's history. In these years, as in the fir period discussed, there was often overlap between private and pul lic with regard to infrastructure construction and service provisio For purposes of clarity, however, in the following discussion diffe ent elements of the infrastructure have been classified as eith public or private.

In the first period, the key developments with regard to public owned systems were improvements in water pumping and distr bution systems; the resolution of key questions in sewerage syste design; achievements in bridge construction that resulted in ou standing structures such as the Eads Bridge in St. Louis (186 1874) and the Brooklyn Bridge (1869-1883); major land-filling pro ects, such as Boston's Back Bay; and the building of extensive urba park systems, following the lead set by Frederick Law Olmstead Central Park in New York City in the 1850s. On the private sid the critical innovations were the building of streetcar systems pov ered by horses; the construction of steam-powered elevated railroac in New York City; the extension of gas distribution systems an the development of improved methods of lighting; innovations i the area of electrical power and lighting systems, including th dynamo, the central station, and the arc and incandescent lamp and the development of telephone systems and the extension of th telegraph network.

In the second period, the critical public infrastructure develo ments include the rapid diffusion of water and sewerage syster throughout the urban network; the development and constructio

of water filtration and sewage treatment facilities; the beautification of city centers; and the planned rebuilding and improvement of streets, roads, parkways, and bridges in order to improve traffic circulation. Among the important largely private accomplishments were the substitution of electricity for horsepower on the streetcars; the building of subways and elevated lines; and the rapid extension of electrical power and telephone systems.

Municipal Provision of Infrastructure

The infrastructure built in the growing cities and suburbs was almost entirely provided at the municipal level (see Figure 1-2). Federal spending for urban public works was relatively minor and consisted largely of river and harbor improvements, lighthouse construction, and public buildings such as post offices and custom houses. Federal expenditures for developmental transportation improvements declined sharply after the 1870s (Aldrich, 1980:F.28-F.32). Although state government expenditures generally increased during the late nineteenth and early twentieth centuries, spending for

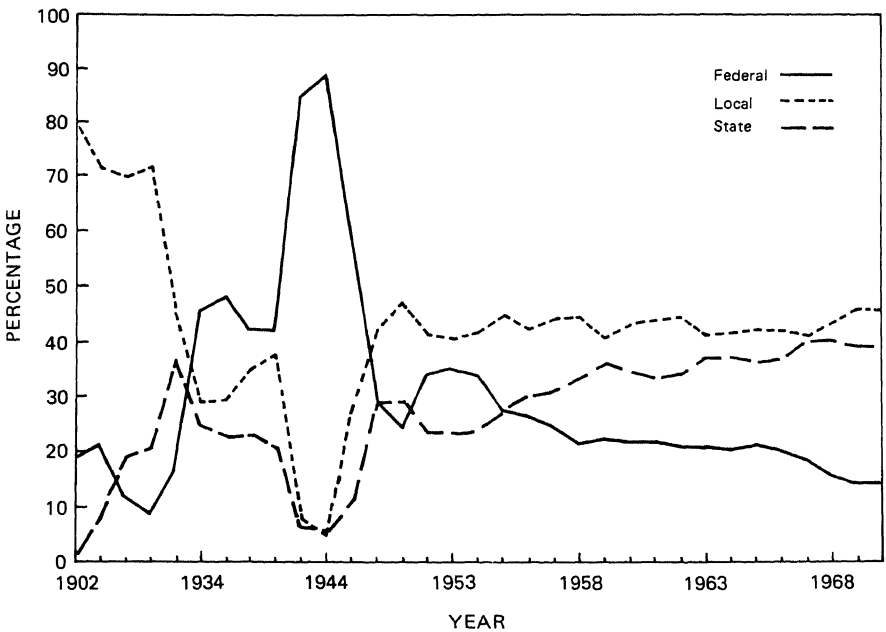

FIGURE 1-2 Public outlays for construction: local, state, and federal, 1902-1970. SOURCE: Based on data from Bureau of the Census (1975:1, 123; 1, 130; 1, 132).

urban public works was relatively minor until highway expend tures accelerated after 1910. More important than direct sta spending was the rise of state regulatory functions in the late nin teenth and early twentieth centuries in the areas of public utilitie transportation, and public health (Wiebe, 1967:164-195).

In general, from the 1850s through the 1880s, infrastructure pr vision was very uneven. The quality of the infrastructure in th larger cities, especially in the East and the Middle West, consi erably exceeded that of smaller cities and southern cities such a Atlanta, Houston, and New Orleans. In these latter locations, di ficult environmental conditions combined with inexperienced ma agers, inadequate technology, and financial limitations to restri the supply of public works to a minimum until after the turn of th century. Similar patterns of poor infrastructure provision were ty ical of most southern cities, where development was hampered b the legacy and debts of the Civil War and Reconstruction, and th West, where newness and a weak financial base restricted infr structure investment (Jackson, 1969:145-203; Platt, 1983:3-74).

In the 1890s and after, urban infrastructure grew rapidly, an technologies diffused down the urban hierarchy to smaller citi and to other regions, although the South continued to lag. Fro 1890 to 1907, for instance, streetcar mileage (almost all private supplied) increased from 5,783 to 34,404 miles, most of it electri powered, and annual rides per urban inhabitant jumped from 11 to 250. With regard to largely publicly supplied technologies, th number of waterworks increased from 1,878 to 9,850 (1890-1920 the population served by filtered water from 310,000 to 17,291,0C (1890-1914), and the miles of sewers from 6,005 to 24,972 (189 1909) (Tarr, 1973:202-212; Tarr et al., 1980:74-76).

Institutional and Political Changes in Infrastructure Supply and Distribution

In many cities, first priority was given to the provision of im proved services to the central business districts. This reflected th concern of the downtown business interests with enhancing pro erty values and remaining competitive with other towns as well a the technological requirements of the new office structures. Th widening of streets, the planting of trees and shrubs, the plannin of parks, and the building of new public buildings and monumen were also part of the so-called City Beautiful movement and helpe

blend city boosterism with a reform thrust. Large-scale public improvements, including the design and broadening of streets and parking facilities, the provision of parks, and the construction of elaborate public buildings, took place in cities like Chicago, Harrisburg, and Kansas City (Fitch, 1966:168-213; Peterson, 1976:430).

Infrastructure was also important to residential development, and here patterns varied by function and by income class. In cities in which municipal resources were especially limited, such as in Birmingham, Alabama, priorities dictated the provision of first-class services for the downtown, while residential areas of the city remained deprived. In new middle- and upper-class areas of other cities, builders usually provided services before dwellings were constructed. In Milwaukee, for instance, the developers assumed the cost of installing services in the expectation of recouping the cost in the purchase price (Harris, 1977:149-153; Simon, 1978:40). In contrast, in the Boston suburban towns, the city (or new metropolitan authorities) provided water and sewer lines after speculators had furnished rough graded streets. Once the utilities were laid, the city would pave and maintain the streets. Such services were provided below cost as a subsidy to the development process and paid for out of general taxes (Warner, 1962:154-155).

The pattern differed somewhat in areas in which builders did not provide the services. In the more affluent neighborhoods, homeowners petitioned the municipality for services immediately after homes were purchased. In the poorer areas, new homeowners delayed the acquisition of sewers, piped-in water, and paved streets in order to keep housing expenses low; in these situations, savings in housing costs were often replaced by health expenses, as householders exposed themselves and their families to infectious disease stemming from inadequate water and sewage services (Simon, 1978:40-41). Another variation came in cities with strong ward-based political machines, in which politics could affect the distribution and provision of services. In some cities, such as Baltimore and Cincinnati, "neighborhood associations" at the turn of the century were successful in ensuring equality of service delivery (Arnold, 1979:3-30).

In many late nineteenth- and early twentieth-century suburbs, the provision of urban infrastructure was beyond the financial capabilities of the towns. In 1890, for instance, only 29 percent of the outlying municipalities of Cook County, Illinois, had piped-in water and 34 percent of those of Allegheny County, Pennsylvania. Many

suburbs were also without sewers, paved streets, or efficient fi e-
fighting services. The absence of these services resulted not o y
in inconvenience but also in public health and fire risks and higl r
fire insurance rates. Faced by these deprivations, inhabitants of
outlying communities throughout the nation voted to merge w h
the central city in order to acquire superior services at a lower co t.
City boosters concerned with the growth of their municipalit s
encouraged these mergers, and in many cases the cities offe d
services to the newly annexed areas at low cost in order to ens e
a positive suburban voter response (Teaford, 1979:32-63).

The rapid development of infrastructure in the late nineteen h
and early twentieth centuries was based on a number of socie -
wide changes. Extremely important during this period was an - -
ganizational revolution that involved the development of lar e-
scale systems affecting the corporate, associational, and techni l
environment. The growth of investment banking, for instance, ma e
supplies of liquid capital more accessible for municipal borrow s
by providing a national bond market. National industry asso -
tions shared technical data and coordinated industry policy, ac -
erating the diffusion of innovations among cities. And vario s
professional organizations such as the American Public Health A -
sociation (1872), the American Water Works Association (188),
and the American Society of Civil Engineers (1852, 1868), us d
their conferences and their journals to agitate for the creation f
local and state boards of health, the improvement of water supp ,
the construction of sewers, the control of pollution, and the pav g
of streets (Wiebe, 1967:111-163).

On the local level, there were also significant organizational a d
institutional changes. Business leaders, for instance, created lar e
numbers of voluntary associations to represent their interests. Boar s
of trade, chambers of commerce, commercial clubs, and other urb a
booster-type organizations pushed for downtown improvements a
order to outdo rival communities. They often joined with sanitaria s
and civil engineers to push for water and sewerage systems in ord r
to improve the public health. Again, the motivation was booste -
ism—a healthy city was more attractive to people and industry th a
one plagued by epidemics (Baker, 1896; Ellis, 1970:354, 358).

On the political side, in the larger cities, machines and boss s
replaced the commercial and upper-class groups who had run m -
nicipal government in the first half of the century. Conceptuall ,
the machine is best understood as having a localized and patronag -

spoils-equity orientation. The power of the machines rested largely on immigrant and working-class votes, obtained in return for services of various kinds. Questions of patronage and spoils became interwoven with the process of infrastructure construction. Machine politicians often owned the construction companies that built the infrastructure and delivered municipal services. In addition, large numbers of the party faithful secured employment on the city payroll, helping to construct and maintain infrastructure projects (Tarr, 1971:62-74).

In many cities in the late nineteenth and early twentieth centuries, whether or not dominated by political machines, politics centered around questions of infrastructure investment. This pattern largely resulted from the fact that cities were in a stage of transition from the older compact, commercial walking city to the new industrial metropolis, with its strong core orientation, spread characteristics, and ring of residential suburbs (Harris, 1977:146-269). Within this context of change, important decisions regarding the quantity, type, and location of infrastructure had to be made. Urban politics, therefore, was often a struggle over both the answers to these questions and the identity of the decision makers.

These political struggles produced waves of reform in the late nineteenth- and early twentieth-century American city. Reformers wanted to change both the character of urban leadership and the nature of the decisions that were made. In the 1880s and 1890s, reformers mainly sought limited changes, such as civil service reform and lower taxes. After the 1890s, however, more sophisticated change-makers attempted to incorporate into urban government the values of efficiency, economy, expertise, and bureaucratic administration that derived from the modern business corporations. Concepts of administrative efficiency developed in Germany were also quite influential (Hays, 1974:6-38; Schiesl, 1977).

The reform thrust produced a number of institutional changes in municipal government between 1900 and 1914. Many cities adopted new charters providing for centralization, strong mayors, and at-large rather than ward-elected councils. In the smaller cities, commission and city manager forms of government were popular. These new structures initially developed because of the inability of existing governments to cope with crisis situations, but their advantages in routine governmental matters caused them to be adopted by hundreds of small- and medium-sized cities. Reformers argued that they would improve the efficiency of infrastructure and service

provision and eliminate political interference. Because city engineers appeared to best represent the values of efficiency, professionalism, and economy that reformers desired, municipalities drew on them extensively as city managers (Schiesl, 1977:181-188; Schultz and McShane, 1978:389-411).

The special district government was another institutional development of this period with strong implications for the provision of infrastructure. These were state creations that had fiscal and administrative independence for special functions. Early special districts were primarily in the areas of water and sewerage, such as the Chicago Sanitary District (1889), the Boston Metropolitan Sewerage Commission and Metropolitan Water Board (1895), and the Passaic Valley Sewerage Commission (1902). The motivation for their formation included the need for a functional structure independent of political boundaries, a desire to escape existing municipal tax and debt limits, and a wish to be free of political control. In addition, special districts were also a means for suburbs to secure central city services without submitting to annexation (Hawkins, 1976a:25; Studenski, 1930:256-262).

A critical issue involving infrastructure that occupied municipal political agendas in the late nineteenth and early twentieth centuries was the question of the private or public ownership of utilities. During the late nineteenth century, electric light and power, gas, and transit became integrated into the urban fabric and became nearly as important to urban functioning as water supplies. Just as piped-in water supplies had earlier shifted from a luxury to a necessity, so now other utility services made the same transformation. Since the majority of waterworks were publicly owned, this suggested to some that the same course should be followed for the other utilities. Many of the most heated political battles of the late nineteenth and early twentieth centuries occurred over the question of the political influence of public utilities, the terms of franchises, and the wisdom of municipal ownership as a means to improve service delivery and provide income for the city (Kirkland, 1961:247-253).

The municipal ownership movement had only limited success. The trend toward public ownership of waterworks continued and rose to 70 percent by World War I, while sewers remained virtually wholly publicly owned. Fierce battles over the municipal takeover of transit companies occurred in many cities, but most companies remained private. In New York and Boston, however, where private

entrepreneurs could not meet the demand for rapid transit, a coalition of leading business leaders, professionals, and reformers secured state approval for a city-financed and -owned but privately operated subway system (Cheape, 1980:152-153). For other utilities, such as electricity and power, municipal ownership was usually confined to small cities (about 1,500 systems by 1912, generating only about 4 percent of electrical power), although again there were exceptions (Cleveland, Kansas City, Los Angeles, and Seattle had municipal light and power plants). Municipally owned telephone companies were found only in small cities and towns, suggesting a lack of entrepreneurial interest in providing service in these localities (Kirkland, 1961:252-253).

There were no clear statistics on the advantages of municipal over private ownership, and disputes usually centered around ideological questions. In order to resolve the controversy, pragmatic reformers shifted toward regulation by state commissioners as a means to ensure service delivery at reasonable rates. Many utilities themselves supported this course. The result of this move toward state regulation of private monopoly enterprise was an actual decrease in the proportionate amount of urban infrastructure provided and maintained by the city itself compared with the private share. Private capitalization of utility enterprises grew at a rapid rate and soon outdistanced municipal debt, even though the latter increased considerably in this period (Platt, 1975).

Financing Infrastructure

Like any long period of history, the years 1855-1910 were characterized by patterns of expansion and recession. Because of the extremely rapid growth of the economy and its relatively uncontrolled nature, adjustments in these years were relatively sharp. Municipal expenditures for infrastructure usually followed these economic swings, but on occasion city governments also attempted to use spending for public works as a means to reduce unemployment and moderate the extremes of the business cycles.

Some of these cycles produced institutional changes and modifications that affected infrastructure construction for many years after the economic downturn had passed. In the period 1866-1873, for instance, postwar economic prosperity and delayed demand resulted in a large expansion of public works building in a number of cities. These projects included infrastructure such as paved streets,

waterworks, and sewers as well as extensive spending for railroad subsidies and investments. Per capita municipal debt increased from $6.36 in 1860 to $13.38 in 1870, at a time when state debt increased from $8.17 to $9.15 (current dollars). A sharp economic downturn in the early 1870s, however, resulted in many municipal failures; at the peak of the depression in 1873, nearly one-fifth of municipal debt was in default (Griffith, 1974:16; Hillhouse, 1935; Studenski and Krooss, 1952:197).

The states responded to municipal financial distress by establishing limitations on municipal debt based on a percentage of assessed valuation, inserting debt limitations in city charters granted in the decade and requiring devices such as sinking funds and voter approval of bonds. By 1880, more than half the states had constitutional limitations on city debt, usually a set proportion of the tax base. Many cities suspended public works improvements and sharply curtailed municipal services. At least one city, New Orleans, sought to relieve itself of its debt burden by leasing out its waterworks (Griffith, 1974:21; Jackson, 1975:147-148).

The widespread urban financial problems in the early 1870s led to what one scholar calls "the first national urban crisis" (Fox, 1977:21-22). This crisis produced not only financial limitations on municipal borrowing but also major attempts to restructure and control urban government. The constitutional doctrines of Judge John F. Dillon heavily influenced the scope of financial limitations and the direction of structural reform. In essence, his doctrines affirmed that the municipal corporation was a mere creature of state government without independent or implied powers. The Dillon rule, as applied, had both political and economic implications. On one hand was the extension of state legislative control (usually Republican) over municipal functions prompted by a distrust of boss and machine politics (usually Democratic); on the other was the assertion of the need for governmental protection of private property rights (Gere, 1982:271-298).

In the remainder of the 1870s and 1880s, financial restrictions limited the actions of municipal governments with regard to infrastructure. In the period 1870-1890, for instance, per capita municipal debt only rose from $13.38 to $14.79 (current dollars) with an actual decrease in the deflationary 1880-1890 decade. In the face of continued high demand for services from growing urban populations, there was a shift from the public provision of capital-intensive infrastructure, such as waterworks, to their private pro-

vision. In the period 1875-1890, for instance, the percent of privately owned waterworks actually increased from 46.5 to 57.1 percent, the only period in our history when the ownership curve moved in that direction. Rather than embarking on large infrastructure projects that required extensive borrowing, cities throughout the country followed the philosophy of pay-as-you-go, and cries of retrenchment, honesty, and efficiency resounded in public buildings everywhere (Anderson, 1980:111; Platt, 1983:13; Studenski and Krooss, 1952:196-198).

In the 1890s, however, and especially after the depression of 1893, municipal spending for infrastructure again accelerated. Driving investment were city boosters, urban reformers, and various professionals who held visions of a new, modern, and sanitary metropolis. The refinement of capital markets and the development of nationwide investment banking provided outlets for municipal bonds, while state legislatures facilitated expansion by granting cities the power to spend on explicit projects, a permissible interpretation of the Dillon rule. In the 1890s, according to one economic historian, the growth of American cities became "the new generative factor" in the American economy (Kirkland, 1961:237). This pattern of heavy municipal expenditure on capital improvements continued through 1914, and by this date spending for infrastructure constituted a much larger share of municipal budgets than it had a half century earlier (Studenski and Krooss, 1952:196).

Engineering and Science Development

Students of innovation generally agree that the factors that bear on the diffusion of new technologies throughout a system are the presence of a body of technically sophisticated people who can understand and implement a new process, the clear advantages of the new process over the old, the reduction of uncertainty and the dissemination of information about a technology, cost advantages of adoption, and the existence of organizations that provide information and assistance regarding a technology, thus speeding its acceptance. Important developments with regard to these factors took place in the late nineteenth century, and by the 1890s they began to generate the diffusion of technologies throughout the urban network and down the urban hierarchy.

Critical to this diffusion was the supply and quality of engineering. A number of urban public works earlier in the century had failed

or operated poorly due to a lack of engineering expertise. In tl
late nineteenth and early twentieth centuries, however, Americ
engineering education developed rapidly and the supply of civ
engineers greatly increased. By 1880 there were 85 schools in whic
engineering was taught, with more than 3,800 graduates in th
1880s. Growth brought professionalization and the creation of
national engineering association, the American Society of Civil Er
gineers (1852, 1868). Municipalities employed a growing numbe
of civil engineers as city engineers and as consultants, and in 189
they and other urban officials formed the American Society of Mu
nicipal Improvements (ASMI). The ASMI was primarily concerne
with technical problems of design and construction and the adoptio
of specifications for various materials (Armstrong et al., 1976:670
674).

An important component of the supply of engineers was the pri
vate consulting engineer, used by municipalities on projects tha
required specialized skills not available in-house or projects fo
which time was restricted. While consulting engineers existed in
the first half of the nineteenth century, the consulting firm was a
product of the second half. Many of the nation's leading sanitary
engineers, for example, Rudolph Hering, Allen Hazen, George
Whipple, and George H. Waring, formed consulting firms and ad-
vised on hundreds of projects throughout the country (Armstrong
et al., 1976:684-686). At the turn of the century the city was the
center of economic activity, and the construction of urban infra-
structure, both public and private, often attracted the nation's best
engineering talent.

On the technological supply side, important advances were made
in both new and old infrastructure areas. The field of water supply
is a good example. Early distribution systems had suffered from
pipe deterioration, but by 1860 the development of improved meth-
ods of manufacturing cast-iron pipe and of coating their interiors
had solved the problem. In addition, after the Civil War, improve-
ments in steam engine design and in pump standardization pro-
vided for steady pressure maintenance. Facilitating the distribution
of these improved methods throughout the urban network were the
marketing practices of the two largest pump manufactures (Holly
and Worthington), who offered municipalities an entire water pack-
age including source recommendations, engineering and construc-
tion plans, and pumps. These two corporations secured franchises
for their systems in thousands of towns and cities (Anderson, 1980:12-
23).

Similar improvements in materials, technological design, and industrial organization occurred in other areas related to urban public works, such as street paving and construction materials, sewer design and pipe material, and energy and communications systems. As the urban network expanded in the late nineteenth and early twentieth centuries, demand and supply interacted to diffuse urban technologies through the system. Improved public works technologies spread to regions such as the South, where urbanization and improvement had previously lagged, and to smaller cities that had just begun to adopt more capital-intensive systems (Armstrong et al., 1976; Fogelson, 1967:85-163; Platt, 1983:75-118).

The U.S. Bureau of the Census attempted to stimulate this diffusion by presenting, beginning in 1902, comparative per capita statistics on the annual operating expenditures for five major municipal functions of cities with more than 30,000 population. These statistics provided estimates of the costs of municipal services that could be used by cities contemplating their adoption or by those that intended to measure their outlays on a comparative basis. The Census Bureau administrators hoped to use the comparative statistics to force cities to improve the quality of municipal service delivery and to eliminate graft and confusion in municipal bookkeeping (Fox, 1977:63-89). Also aiding in the diffusion of administrative improvements was the New York Bureau of Municipal Research (founded in 1906), an investigatory reform group that was emulated in a number of other cities (Schiesl, 1977:111-132).

As technologies spread throughout the urban network, they often created unforeseen problems. Most municipalities that constructed sewerage systems discharged their sewage into adjacent streams, thereby polluting the water supply of downstream cities. This was a striking example of how a technology adopted for beneficial purposes in one locality could cause severe health problems in another location. This problem was linked to the belief that running water purified itself and the absence of state authority that could constrain cities from contaminating each other's metabolic systems. The development of water filtration and sewage treatment technologies and of chlorination eventually mitigated the public health hazards and nuisances created by municipal sewage disposal practices, thereby reflecting the importance of science-based inputs in controlling infrastructure-produced externalities. These new technologies were a result of experimentation by biologists, chemists, and sanitary engineers at laboratories such as the Massachusetts State Lawrence Experiment Station. Thus, after the 1890s, water

filtration and sewage treatment plants became important components of the urban infrastructure, although diffusion of sewage treatment systems was much slower than that of water filtration systems (Tarr et al., 1980:69-78).

Throughout the nation, cities took note of the importance of scientific investigation and technical expertise to both the public health and the quality of the infrastructure. In the late 1880s and 1890s, public health authorities secured the establishment of bacterial laboratories at Ann Arbor, Cincinnati, Milwaukee, New York City, and Providence. In the early twentieth century, city testing laboratories were created in Cincinnati, Rochester, and Pittsburgh to analyze the quality of the materials sold the municipality and to establish uniformity of standards.[4] The majority of cities, however, had neither laboratories nor testing facilities and depended on their city engineers or consulting engineers for technical and scientific information.

Bringing engineering talent to the city was a difficult task. Many engineers avoided municipal employment because of a concern over corrupt politics, low status, and higher private-sector salaries. In a few cities such as Cleveland and Philadelphia, the local engineering societies attempted to influence decisions concerning infrastructure and pollution control by establishing committees on subjects such as streets, sewers, and smoke control (Layton, 1971:115-116). In many cities, however, local engineering societies would not involve themselves in public-sector questions because they viewed such activity as a violation of their professionalism. Little is known about the recruitment of municipal engineers and how they compared with their private-sector colleagues. Some city engineers obviously faced uncertain tenure and were subject to political interference, but others held office throughout many political changes and managed their systems effectively. In many smaller and middle-sized cities, they regularly assumed managerial positions (Armstrong et al., 1976:686; Teaford, 1982:137-139).

THE DOMINATION OF THE AUTOMOBILE AND THE ENLARGEMENT OF THE FEDERAL ROLE, 1910-1956

Two factors, one technological and the other governmental, pri-

[4] For discussions of the establishment of bacterial laboratories, see Duffy (1974:91-111) and Leavitt (1982:177); for materials testing labs, see Fisher (1933:168-169).

marily affected urban infrastructure developments from 1910 to 1956. The critical technological innovation was the internal combustion engine, used most importantly in the automobile, the motor truck, and the motor bus. This innovation generated a host of social, spatial, and administrative developments that sharply altered the pattern of urban life. With regard to governmental developments, the crucial shift involved an enlarged role for the federal government, beginning in the 1930s in the New Deal and continuing in the postwar period at a reduced level of investment (see Figure 1-2). Although there were numerous other technological and administrative innovations that affected urban infrastructure during these years, the explosion of automobile usage and the altered role of the federal government are the most critical factors.

The Automobile Revolution, 1910-1930

During the years from 1910-1930, the nation's auto registrations rose from 458,000 to nearly 22 million, or from one car to every 201 persons to one car to every 5.3 persons. The development of the motor vehicle occurred at a time of rapid urbanization, and automobiles, trucks, and buses became largely concentrated in cities in the 1920s, although rural areas were also substantially affected. The automobile had a dramatic impact on the urban fabric and infrastructure. It greatly accelerated the process of deconcentration initiated by the streetcar, caused a vast increase in the flow of commuter traffic between the downtown and suburban residential areas, and sharply increased congestion in the downtown cores. This radical innovation promoted massive alterations in the urban infrastructure, primarily the construction and improvement of roads and highways, the development of traffic systems, the building of bridges and tunnels, and the widening and reconstruction of downtown streets (Rae, 1971:40-59).

As automobile usage grew in the 1920s, traffic problems within the core of cities greatly increased. In Pittsburgh, for instance, between 1917 and 1929, the number of automobiles in the central business district increased 587 percent, the number of motor trucks 251 percent, and the number of streetcars 81 percent. Downtown business groups throughout the nation called for planning to alleviate traffic congestion and for new road networks to facilitate entry into downtown areas and to permit the bypass of through

traffic. These same interests often also called for rapid transit construction to facilitate the transport of people in and out of the core (Foster, 1981:65-115; Tarr, 1978:26-28).

Planners and members of the new engineering subdiscipline of traffic engineering, developed primarily in response to the automobile, viewed downtown congestion as an engineering problem, requiring both planning and public works construction. Automobile-induced changes in the central business district included the widening and double-decking of streets, the elimination of grade crossings, and the development of a variety of traffic controls. In addition, street surfacing with smooth pavements (mostly asphalt) took place throughout urban areas; Chicago alone spent $450 million on street improvements between 1913 and 1937. Cities and counties also built hundreds of bridges and tunnels to facilitate cross-river transportation, while Chicago, New York, Pittsburgh, and Los Angeles constructed limited access roadways into the downtown area (Condit, 1973:249-252; Tarr, 1978:25-31; Weingold, 1980).

The outlying areas of cities and their suburbs were the other major areas strongly impacted by the automobile. Urban growth along streetcar lines radiating from the central business district often left large tracts of land undeveloped near the periphery. The flexibility of the automobile facilitated development of these areas. In addition, the automobile stimulated extensive development of the urban fringe. The 1920s witnessed the emergence of the modern automobile-dependent residential suburb, with numerous new towns and villages appearing outside large cities and older suburbs undergoing increased growth. In the newer spread cities that lacked strong downtown business districts, such as Los Angeles and Denver, the automobile became the primary shaping element, and the dense patterns of development characteristic of the older eastern cities never materialized (Anderson, 1977:87-104; Muller, 1981:19-60; Tarr, 1978:31-34).

The needs of the automobile, motor truck, and bus for improved roads and highways, expressed by automobile clubs, business organizations, and engineering associations, resulted in extensive construction. While total highway mileage increased only slightly in the 1920s, from 235,000 to 250,000 and total national mileage from 3.16 to 3.25 million, the mileage of surfaced roads increased 157 percent and high-grade surfaced roads 776 percent between 1914 and 1929 (Rae, 1971:354). The Bureau of Public Roads, aided by the American Road Builders' Association, the American Society

for Municipal Improvements, and the American Society of Civil Engineers, developed standards and specifications that were often used in designing new roadways and the rebuilding and resurfacing of highways and streets. Except for a few cases, however, such as Westchester County's Bronx River Expressway, Chicago's Outer Drive, and the New York parkways developed by Robert Moses, most highways had a conventional two-lane pattern without limited access (Rae, 1971:60-83; Seely, 1982).

In order to cope with the massive needs of the automobile, government required new financial instruments. From 1920 to 1930, the value of highway, road, and street construction increased from $738 million to $3.0 billion (expressed in constant 1957-1959 dollars). Two innovations were important: an increase in federal aid and massive state involvement in road building. Beginning in 1916, Congress began authorizing expenditures for road construction (up to $75 million for 5 years) provided that the states match federal dollar expenditures on a dollar-for-dollar basis and administer federal grants through a highway department. By 1917, each state had created a road agency, usually staffed by civil engineers. In addition, in order to receive federal aid, states had to designate 7 percent of their rural mileage for inclusion in a federal network. State road agencies and the Federal Bureau of Public Roads also cooperated to produce uniform route marking (Rose, 1979:8-9).

State adoption of the gasoline tax, beginning with Oregon in 1919, was of much larger importance than federal aid in the 1920s. By 1929, all states had enacted the tax, which became the principal source of highway revenues. These user fees provided 60 percent of the increase in highway expenditures between 1913 and 1930, with other funds provided from bond issues and general taxes. By 1930, state gasoline taxes and motor vehicle and operators' licenses provided over 40 percent of state revenues (Aldrich, 1980:F.46; Rae, 1971:69-70).

Municipal expenditures for streets and highways also rose, although cities depended largely on conventional means of financing such as bonds, the property tax, or special assessments to provide improvements. In the 1920s, municipal operating and capital expenditures for streets and highways were only exceeded by spending for education (Aldrich, 1980:107). Cities, counties, and other governmental authorities cooperated to improve transportation infrastructure. In New York's Westchester County, for example, the city authorities joined with the Bronx Parkway Commission to build a

limited access parkway and sewer system along the Bronx River. In Pittsburgh, the county embarked on a large bridge-building program and coordinated it with city construction of a limited access roadway connecting the suburbs and downtown (Tarr, 1978:28-31; Weingold, 1980).

Infrastructure construction in a number of other areas accompanied the road-building boom of the decade. School-building construction accelerated in order to accommodate a 41 percent increase in school-age population. Funds committed to sewers and waterworks tripled, while public health and water quality considerations caused the population served by treated water and sewage treatment to more than double. While taxation largely paid for highway construction, a large fraction of other infrastructure development was debt-financed. From 1922 to 1932, per capita municipal debt increased from about $71 to $123, while per capita state debt increased from $8.64 to $9.17 (current dollars). But while state and local expenditures for infrastructure advanced rapidly, federal investment reached its lowest point since the Civil War, with the federal share of the cost of total government construction amounting to only 11.2 percent (Aldrich, 1980:F.47; Hillhouse, 1936:36).

The demand for the construction of public works in the 1920s came largely from a renewed burst of city boosterism, reflected in the activities of downtown business interests, chambers of commerce, and other business organizations. In addition, real estate developers on the urban periphery pushed for roads and services. Various professional associations, such as the American Society for Municipal Improvements, the American Water Works Association, the American Society of Civil Engineers, and the International Association of Public Works Officials, were also influential in arguing for infrastructure development in areas of their professional interest. Even though such concepts as the "city efficient" and "functional" government were in vogue in the 1920s, political machines persisted in the larger cities and were responsible for considerable infrastructure construction. As Carl Condit notes, "even Chicago's 'Big Bill' Thompson had his name on the bronze plaques that identify some of the greatest works of civic art in America" (Brownell, 1975; Condit, 1973:206; Glaab, 1968:399-438).

In order to improve efficiency of operation and service delivery, many cities adopted governmental changes proposed originally in the reform period before World War I. These new forms, such as the commission and city-manager governments and at-large and

nonpartisan elections, promised that government would be run by professionally trained administrators, who used objective, businesslike criteria such as economy and efficiency to make public decisions. These governmental innovations were widely adopted in the newer western cities and in suburban communities. Even the older eastern cities adopted reforms such as improvements in accounting and budgetary procedures. One student of municipal government observes that the statistics on city services suggest that cities made significant improvements in the effectiveness of their administrative practices between 1912 and 1930, years of large structural changes (Fox, 1977:106; Gluck and Meister, 1979:97).

During the 1920s, urban territorial growth slackened, and the combined areas of the nation's 20 most populous cities increased only 10 percent. This compares with increases of at least 18 percent per decade from 1870 to 1900 for the top 20 cities. While cities continued to grow in population, the percentage of the metropolitan population living in the central city declined. Central cities found it increasingly difficult to absorb towns on their periphery, and suburbs no longer sought annexation or consolidation with central cities because of a desire for superior municipal services (Teaford, 1979:77).

Many of the larger and older suburbs developed their own services in the decade of the 1920s, aided by strengthened municipal bond markets, improved technology, and relaxed state restrictions on borrowing. Throughout the country, suburbs developed their own infrastructure. In 1915, for instance, only 45 percent of the Cook County cities and towns had a public water supply, but, by 1934, 85 percent of the municipalities within a 50-mile radius of Chicago had such service. Other services, such as electric lights, sewers, and fire and police departments, also became commonplace in the suburbs (Teaford, 1979:78-79; Rose and Clark, 1979:340-364).

Adoptions of special district government expanded in this period as a means of infrastructure development and service delivery. These structures further undermined the competitive advantage of the central city with regard to services. While metropolitan cooperation reduced the financial burden of infrastructure on the central city by spreading costs, it also removed an incentive for suburbs to consolidate with central cities. Legislation permitting intergovernmental contractual relationships for such projects as joint sewage and water systems provided for more efficient services and furnished a further disincentive for annexation.

The 1920s also witnessed an increased role by county governments with regard to infrastructure. Counties throughout the nation constructed highways, bridges, and tunnels. In Allegheny County, Pennsylvania, for instance, the county constructed six major bridges, many minor bridges, and the nation's longest land automobile tunnel and sponsored a Major Highway Plan. Urban and suburban counties created extensive park systems and recreational facilities, constructed sewers, and even in a few cases provided water supplies for suburban residents. From 1913 to 1932, county government spending in 96 metropolitan areas increased from 16 to 21 percent of combined county-municipal expenditures (Teaford, 1979:79-8).

The New Deal

The New Deal evolved as a governmental response to the economic hardships caused by the Great Depression. Cities were especially hard hit by the sharp contraction after 1929, and a number of cities either defaulted or were close to bankruptcy. As a result of the policies of President Franklin D. Roosevelt, the federal government assumed for the first time a predominant role in the construction of urban infrastructure.

The rationale for such intervention included federal acceptance of the obligation to relieve mass employment; the use of public works to provide a yardstick by which to measure the performance of private enterprise; and the use of public construction to "prime the pump" (Aldrich, 1980:F.49). None of these ideas was completely new. That is, public works had been used to soften the effects of unemployment in cities during earlier depressions; the yardstick idea had been applied in the past, especially with regard to municipal utilities; and public construction had been used to stimulate enterprise. What differed in the 1930s was the massive scale of federal involvement, amounting to 60 to 65 percent of all public construction from 1933 to 1938 and nearly a third of total construction (Aldrich, 1980:F.50; Gelfand, 1975:23-105).

The federal government constructed a huge range of projects, including roads, sewers, waterworks, multiple-purpose dams, bridges, parks, docks, airports, hospitals, and other public buildings and "prevented what would have been near eclipse of an entire generation of public construction projects" (Aldrich, 1980:F.55; Daniel, 1975:2-11).

It is instructive to look at the Public Works Administration (PWA

sewer and water supply projects. PWA funds accounted for 35 to 50 percent of all new sewer and water supply construction during the 1930s. These projects generated a variety of benefits to local communities. New water supply systems, for instance, produced sharply reduced fire insurance premiums in addition to water supplies. Sewer construction supplied unemployment relief and also addressed the problems of water pollution control. President Roosevelt accelerated investment for sewage treatment facilities by refusing to approve PWA sewer projects that did not include treatment. Similarly, the Works Progress Administration (WPA) was not permitted to construct sanitary sewers unless they were designed to be compatible with treatment works. By 1938, federal financing had aided in the construction of 1,165 of the 1,310 new municipal sewage treatment plants built in the decade. The population served by sewage treatment increased from 21.5 million in 1932 to more than 39 million by 1939, substantially improving the quality of the waterways used for municipal waste disposal (Tarr, 1978:Ch. 8:12-19).

On the whole, federal public works spending was oriented toward the Mountain, Pacific, and Southern states. The Mid-Atlantic and East North Central states, all of which had per capita incomes above the national average, received less than the national average of public works employment. These statistics, however, are an artifact of the existence of large conservation projects, such as the Tennessee Valley Authority and Bonneville and Hoover dams, in the West and the South. PWA projects involving hospitals, sewers, educational buildings, and water supply were more concentrated in the urbanized areas of the Mid-Atlantic and East North Central states (Daniels, 1975:12-17).

The shift of infrastructure funding from the local to the national level in the 1930s did not eliminate politics in its allocation and utilization. In Chicago, Kansas City, and Pittsburgh, for example, the New Deal stimulated a Democratic voting revolution that helped put Democratic political machines into power. The machines utilized the patronage and projects of the Civil Works Administration (CWA), the WPA, and the PWA to entrench themselves. In Kansas City, for instance, the Pendergast machine directed the hiring of thousands of workers under the CWA and the WPA. The WPA produced a number of new municipal buildings in Kansas City, most of which included cement from Boss Pendergast's cement company. Chicago received more public monies than any other city,

benefiting from the fact that it had both a comprehensive dev l-
opment plan and a huge Democratic majority. The machine direct d
by Mayor Edward J. Kelley received substantial patronage, a d
the city acquired large additions to its infrastructure, such as bc t-
levards, bridges, public transport, and water and sewage impro: :-
ments (Dorsett, 1977).

Professional Developments

The 1920s and 1930s saw the continuation of the trend for m -
nicipal engineers to become city managers, especially in small r
cities. Large-city managers were less likely to be engineers becau :
of a requirement for administrative training on a broader scale, b t
engineers usually served as public works administrators, even thou: ı
engineering knowledge was only a part of the qualifications r -
quired of large-city public works directors. The depression affect l
engineers more than other professionals, and it is likely that th :
qualifications of engineers working on public infrastructure co: -
struction and maintenance improved because of the scarcity of pr
vate-sector postions. A 1962 survey showed that "security" and th
unavailability of other jobs were the prime reasons why many ir
dividuals accepted government employment during the depressio
(Armstrong et al., 1976:681-684).

The two decades between the wars also saw important develo: ments with regard to various professional and public interest o: ganizations most concerned with the urban infrastructure. Th American Society of Municipal Engineers (AME), for instance, joine with the International Association of Public Works Officials (IAPWO in 1925 (it was originally the International Association of Stree and Sanitation Officials, founded in 1919). In 1931 the IAPW(began cooperating with the International City Managers Associa tion to design a national cost accounting and reporting system t facilitate the planning, programming, and budgeting of public works The outgrowth of this collaboration was a number of demonstratior projects and the publication of a text entitled *Municipal Publi Works Management*. In 1937 the AME and IAPWO joined to form the American Public Works Association (APWA) under the lead- ership of Donald C. Stone. This association was located at the same Chicago address with many other professional and public interest associations, and this public administration center became the focus for the circulation of information on new administrative procedures.

Such associations worked for the enactment of standards with regard to the infrastructure as well as for more government spending on infrastructure in general (Armstrong et al., 1976:679-681).

The Postwar Period

The postwar decades witnessed increased suburbanization and the beginnings of central city decline. The effects of this trend were masked for a time by a backlog of war-induced infrastructure needs that produced a period of vigorous growth. During the war itself, federal public works investment was almost entirely for factory plant and equipment, and municipal spending for construction and maintenance was sharply reduced. By 1945, public construction for infrastructure had a total shortfall of 3.3 years of building at 1940 levels. Public investment for infrastructure resumed after the war, expanding from $2.9 billion in 1946 to $8.6 billion in 1950, to $13.6 billion in 1960 (1957-1959 constant dollars). Construction of sewers and waterworks, school buildings, and roads proceeded at a rapid pace, reflecting the impacts of suburbanization, the automobile, and the baby boom (Aldrich, 1980:F.59-71).

Central city decline and suburban proliferation created different sorts of infrastructure pressures. Suburbanization produced an increase in the formation of municipalities in many metropolitan areas. In suburban Saint Louis County, for instance, the number of municipalities grew from 21 in 1930 to 83 in 1950; in Los Angeles County the number went from 45 to 68 in the 1950s. In medium-sized cities of the West and the South after 1945, annexation of adjacent suburbs often occurred, but this route was politically impossible for the older urban centers. The loss of population, industry, and commercial activities by these centers caused a severe weakening of their tax bases. Except in a few cities, attempts to deal with these problems by forming metropolitan governments also failed (Teaford, 1979:171-176).

Policy makers often tried to cope with fragmentation by expanding old and creating new special-purpose metropolitan districts. Of the 79 metropolitan special-purpose districts existing in 1956, 51 were formed after 1930. Such districts dealt with sewage disposal, transportation, water, parks, and recreation and brought scale efficiencies and improved services to many metropolitan areas. The special districts also created a new governmental layer, often outside the control of the citizens who depended on their services. As

separate organizational bureaucracies, frequently possessing financial independence through user fees, they occasionally acted in arbitrary and insensitive fashion in expanding their operations and providing services. In cases in which central cities still supplied services to suburbs, friction resulted over questions of rates and quality of service delivery. Special district governments were not always the panacea for solving infrastructure problems they were promised to be (Hawkins, 1976b:171-186).

In response to metropolitan fragmentation, the functions of county government also expanded in the postwar period. In 1954, for example, Los Angeles County contracted to provide all administrative services to the suburban city of Lakewood, and a score of other suburban cities in metropolitan Los Angeles followed the example. By 1972, of the 150 major urban counties, more than half provided public libraries and recreational facilities, over a third sewage disposal, and about a fifth solid waste collection and water supply. Such county activities were advanced by state legislation that permitted the county to act in place of the municipality (Teaford, 1979:174-175).

Faced by rapid suburbanization and central city decline, downtown business interests and urban politicians joined to attempt to revitalize the central business districts. These developments began in the older cities of the East and the Midwest but spread to the so-called Sunbelt in the 1960s and 1970s. In a number of cities, such as Pittsburgh, Baltimore, Atlanta, Dallas, Minneapolis, and Chicago, the renewal efforts involved significant interaction between private-sector voluntary business organizations and the public sector. In some cases, such as Chicago and Pittsburgh, urban government was controlled by a Democratic political machine, while the business establishment was strongly Republican. A common interest in development, however, overwhelmed partisan prejudices. In several Sunbelt cities, such as San Antonio and Norfolk, political "reformers" joined with business leaders to promote renewal (Abbott, 1981:120-166; Fosler and Berger, 1982).

These city "booster" coalitions hoped to revive the central business districts, stimulate the return of the middle classes, and improve the economic climate of the central city. Their programs largely involved a combination of private-sector investment in office structures with public-sector investment in supporting infrastructure. Attempts were also made to improve environmental conditions.

Thus, in Pittsburgh, whose redevelopment efforts became a model for a number of other cites, the Allegheny County Conference on Community Development, composed of the city's business elite led by Richard King Mellon, cooperated with the Democratic political organization under Mayor David Lawrence to bring about the so-called Renaissance. Essentially this involved cooperation to eliminate smoke pollution of the air and sewage pollution of the rivers, to control flooding, to renew the central business district as a corporate headquarters center, and to improve the highway network. Some projects, such as sewage treatment, involved suburban towns as well as the central city. Special authorities, created by state legislation and directed by a mix of public- and private-sector representatives, were the predominant government mode used to bring about the Pittsburgh Renaissance (Stewman and Tarr, 1982:59-78).

The immediate postwar renewal efforts did not involve large numbers of federal dollars. In those years there was a reaction against the spending of the New Deal, although federal involvement in the cities and in infrastructure never completely stopped. A number of downtown renewal projects, for instance, rested on the authority and funds provided by the 1949 Housing Act and subsequent amendments in 1954 and 1959. While most of the funds in these acts were for land assembly and clearance, site preparation, including infrastructure, was also included (Gelfand, 1975:205-216).

In the area of water quality, federal involvement came haltingly, especially compared with the heavy investment of the 1930s. The Federal Water Pollution Control Act of 1948 provided funds for research and planning, and for low-interest loans, while the 1956 amendment enlarged federal participation by providing grants to stimulate the construction of municipal sewage treatment facilities. The dollars available for subsidy remained limited, however, due to a belief that federal grants actually retarded the pace of municipal investments. Total spending on new construction for sewer and water systems did not actually reach the 1930 level in constant dollars until 1951. From 1950 to 1960, at a time when federal aid was relatively nominal and municipalities provided most investment, spending increased about one-third, from $1.1 billion to $1.4 billion (1957-1959 constant dollars) (Bureau of the Census, 1975:621; Tarr et al., 1978:Ch. 7:22-26).

The pattern of rapid suburbanization caused spending for highway construction to expand dramatically. Federal dollars were

available in limited amounts under the Federal-Aid Highway A of 1944, which allocated funds on a 50-50 matching basis, but higl way needs, both in terms of new roads and repair of old, wei immense. A number of states, for example, Illinois, Ohio, and Penı sylvania, constructed toll roads (3,338 miles by 1963) to solve th problem of financing intercity transportation. Leaders of renewa coalitions in cities such as Pittsburgh, New Haven, and St. Pau regarded urban expressways as critical to redevelopment and funde them through state or municipal bond issues. In 1955, urban gov ernments sold $310 million in bonds for highway construction (Rose 1979:65).

Given the scope of urban and national highway needs, however some sort of federal involvement was necessary. Urban spokesmei observed that federal financial responsibility for new interstate highways would have the additional benefit of freeing up local anc state funds for maintenance and for the construction of secondary and urban road networks.

Throughout the 1950s, truckers, automobile clubs, highway contractors, the automobile industry, engineering associations, and business groups lobbied Congress to provide federal funding for new highway construction. The Advisory Committee on a National Highway Program, headed by retired General Lucius D. Clay, recommended that both national security and the health of the economy were dependent on rapid construction of the highway network, and Congress finally approved the bill in 1956. The final legislation provided for federal assumption of 90 percent of the costs, with gasoline tax revenues placed in a Highway Trust Fund to prevent diversion.

The 41,000-mile network created by the Interstate Highway Act was the largest single item of infrastructure ever projected. Congress gave little consideration, however, to the effects of its construction on urban areas. The Clay Committee had sold the interstate system to Congress as a carrier of long-haul traffic, but municipal leaders visualized the highways as a means to solve traffic congestion problems. Because highway construction through congested urban areas was exceedingly expensive, cities eventually received a large percentage of the total allocations. The interstates, however, although they speeded commuter traffic in some urban areas, also accelerated central city decline by making it easier for residents to move to the suburban fringe and still commute to central city workplaces (Gelfand, 1975:222-229; Rose, 1979:70-84).

THE RISE OF THE OUTER CITY AND RECENT TRENDS INFLUENCING URBAN INFRASTRUCTURE, 1956-1982

Several interrelated demographic, fiscal, and social trends have severely affected urban infrastructure in the 1960s and 1970s. Central city population loss and the movement to the suburbs has continued at a rapid rate. In some cases this migration has produced metropolitan as well as central city decline. While processes of change, such as gentrification and renewal of central business districts as well as rising gasoline prices, have resulted in some return migration to the city, the numbers are still relatively small. Accompanying central city losses has been a massive regional population shift from the older cities of the Northeast and the Midwest toward the cities of the Sunbelt (Abbott, 1981:34-56; Muller, 1981:119-182). The most important consequence for the urban infrastructure of these population trends has been a decline in tax revenues to support maintenance and renewal.

While what is now called the inner city has been experiencing often dramatic population declines, the so-called outer city is undergoing a continuing boom. Traditional suburbia as well as exurbia have attracted a mass of urban activities that were formerly a central city monopoly. Most prominent in the outer city are the new multiple-purpose centers (or mini-cities) that provide concentrations of retailing, entertainment, and other employment activities. These are located on or close to the beltways and freeways constructed since the 1956 Interstate Highway Act and are surrounded by residential areas (Muller, 1981:119-182). In many cases, infrastructure is provided by special-purpose authorities who levy user taxes and are better able to absorb the costs of maintenance and construction. But while some of the outer city infrastructure fits the decentralized nature of the low-density, outer city habitat, much of the technology was originally developed to fit the needs of a more concentrated environment. The expense of utilizing these technologies in a dispersed environment raises important questions of economies of scale and of the compatibility of technical systems.

Changing Fiscal Trends

Changing fiscal trends have also been critical in the 1960s and 1970s. In these decades the federal government returned to the pattern of heavy involvement with the infrastructure that it had

followed in the middle of the nineteenth century and during the Great Depression (see Figure 1-2). From 1957 to 1977, federal grants to state and local governments for capital projects increased from about 10 percent of public works investment to about 40 percent. Highways, sewers, and spending for mass transit absorbed the largest amount of federal funds (CONSAD, 1980:I.80-I.125). This reliance on federal dollars, claim some urban authorities, has produced a sharp change in the nature of federalism and a skewing of local priorities toward projects for which federal funds have been available. Perhaps most critical for the health of infrastructure has been a bias in the legislation in favor of new construction rather than maintenance of existing capital stock (CONSAD, 1980:I.125). Beginning in 1979, federal funding for infrastructure began to decline in response to pressure on the federal budget from inflation. Initially, the Reagan administration sharply curtailed the supply of federal funds for infrastructure, forcing municipalities and other institutions to depend more heavily on their own resources. In 1982, however, it acquiesced to an increase in the gasoline tax for transportation facilities. While federal funding has fallen since 1979, local governments have experienced revenue shortfalls since the early 1970s that have severely restricted their ability to undertake infrastructure funding (American Public Works Association, 1981).

The Environmental Movement

The environmental movement is the third major factor that affected urban infrastructure in the 1960s and 1970s. The environmental movement is a political action movement led by upper- and middle-class professionals and activists that aims to improve environmental conditions largely through government action. Under various acts, such as the Federal Water Pollution Control Act of 1972 (PL 92-500), federal dollars poured into sewer and sewage treatment projects. Between 1967 and 1977, federal expenditures for sewer systems increased from $150 million to $4.1 billion, with the heaviest expenditures after 1973. By 1977, transfers to localities for wastewater treatment composed 30 percent of federal aid to cities and more than half of the total combined local and federal new investment in sewer systems. Simultaneously, localities themselves increased their sewer investments, from about 11 percent of capital infrastructure expenditures in 1959-1972 to 21 percent in

1977 (Choate and Walter, 1981:40-47; CONSAD, 1980:I.85-I.104). The National Environmental Protection Act, which required the preparation of environmental impact statements for projects involving federal money, was another environmentally related federal act that affected urban infrastructure. While its provisions may have improved environmental quality by requiring the alteration or halting of construction projects, they also lengthened the time (and hence increased the cost) required for project completion.

Mass Transit

The involvement of the federal government in the provision of funds for urban mass transit is another critical infrastructure development in the 1970s. Between 1973 and 1977, federal funds to localities for urban mass transit grew from $275 million to $1.3 billion. This development relates to a long-term historical change that began early in the century and accelerated in the 1950s from private to public provision of transit services. By 1965, more than half of the nation's urban transit systems were publicly owned. The transit industry as a whole developed an operating deficit for the first time in 1963, although a number of transit companies had had severe financial problems early in the century (McShane, 1974:34-39). Some advocates of public ownership of transit lines argued that cost savings and better service would result—an argument that had originally been used at the turn of the century in the drive for municipal ownership. Government involvement in public transportation, however, has generally appeared to accelerate, not diminish, spending. Transit subsidy levels were relatively low until the mid-1970s, but then rose sharply (Altshuler et al., 1979:31-49).

Alternative Systems

A fifth characteristic of the 1970s with regard to infrastructure has been an emphasis on innovation and alternative systems, stimulated by the sharply rising costs of municipal services. Also contributing, however, have been increased research activities and a recognition of the diseconomies that often accompany large-scale systems. Ideas stemming from the environmental movement had much to do with these developments. Several examples of innovation are experiments with land disposal of sewage (Corps of Engineers), on-site alternatives to conventional sewerage systems (En-

vironmental Protection Agency), and paratransit systems (Urban Mass Transportation Administration). The Environmental Protection Agency began a technology transfer program in the early 1970s, and some federal legislation actually mandated consideration of alternative systems (Office of Technology Assessment, 1981).

CONCLUSION

It is clear from an examination of the historical record that infrastructure has played a critical role in urban development in each of the periods surveyed. It is also apparent that infrastructure provision has been affected by a number of different demand and supply factors. Important on the demand side have been the activities of city boosters and the downtown business establishments, real estate developers, urban politicians, contractors, suppliers of materials, and various professional groups. The motivation of each group often varied. City boosters wanted to enhance the image of their cities in order to attract population and industry. Real estate developers wanted to increase the value of their property through improvements. Politicians wanted to secure contracts for themselves and jobs and benefits for their constituents. Professionals, such as engineers and physicians at the turn of the century, pushed technologies relating to public health in order to improve urban health and vitality for professional and employment reasons.

On the supply side, the important factors have included finances, the supply of engineers, the flow of innovations, and the administrative delivery structures. The financial pattern was cyclical and usually related to the building cycle and to longer cycles of about 15-20 years (Gottlieb, 1976). Over time, there were also important shifts in the funding sources, as state and federal governments joined with municipalities in infrastructure provision for purposes of stimulating development, employing the out-of-work, improving the public health and the environment, and satisfying various political and voting groups. The supply of engineers increased over time, making possible larger and more complex projects, but it is probable that in recent decades the private sector and other newer branches of engineering have become more attractive to talented engineers than public-sector employment. Forms of delivery systems have also shifted, from a reliance on volunteer and labor-intensive services in the early nineteenth century to more structured and often capital-intensive systems beginning in the latter part of the nineteenth century. Turn-of-the-century urban reform-

ers pushed for new governmental forms oriented toward efficiency and economy, and administrative systems improved in many cities. Reform systems, however, had more success in small and medium-sized rather than large cities. Perhaps the governmental organization that best reflected the administrative ideal was the special district authority, free from the political and financial constraints of older cities. This form of management proliferated in the outer city settlements that have developed in recent decades.

Today's so-called infrastructure crisis has produced a variety of innovations and experiments with regard to financing, public-private cooperation, and various types of lease-back, sell-back, and private-sector options. Many of these experiments, however, had been tried at different times in the past, usually in response to financial stringency. The fact that some of these options have been used before does not vitiate their effectiveness but reaffirms the cyclical nature of the urban infrastructure experience. The history clearly affirms that a variety of forms and approaches have been used over time in order to supply urban needs. Public provision, private provision, and public-private cooperation have all been attempted and have been both successful and unsuccessful, depending on the particular time, place, and circumstances.

This brief examination of the evolution of the urban infrastructure has indicated the extent to which the integrity of the infrastructure as a working system is dependent on a wide range of political, technical, financial, and demographic factors. The built environment, including both private and public elements, is very slow to change, and the largely public urban infrastructure is even slower. The more radical systemic changes, such as the shift from the privy vault/cesspool system to sewerage, from wells and pumps to waterworks, and from a fragmented system of national highways to the interstate highway system, depended on interest group coalitions on the demand side and the existence of technical expertise and financial resources on the supply side. These major systemic shifts, of course, took several decades to occur. History suggests that if major renovations and alterations in today's infrastructure are to occur, a powerful coalition of interest groups, sensitized to the need for innovation, will be required.

AFTERWORD

While the literature on urban infrastructure is relatively large, it is extremely uneven and focuses on isolated episodes in the history

of specific cities. Seldom does it provide a comparative framework. There are a number of specific infrastructure topics that should be investigated, but even more important is the need to focus on the relationship of infrastructure to the processes of urban change and development. The following list discusses some areas that are in need of investigation, but in no particular order of importance.

- The relationship between infrastructure construction and development: History suggests that there is a strong correlation between the construction of infrastructure and economic development. We still lack studies, however, especially with regard to cities, that support this hypothesis in a systematic way.
- The operation of urban real estate markets in relationship to infrastructure development: We are badly in need of micro-studies that relate changes in real estate development and values to development of infrastructure over time. We have information on two or three cities that suggests a great variation over cities and social classes, but more is needed.
- Infrastructure maintenance: "Spending money unstintedly for construction, often under the supervision of the best engineers the country affords, and then being niggardly in maintenance and operation appropriations and leaving costly and perhaps complicated works to run themselves except for political heelers or lame ducks is the rule rather than the exception in many if not most American cities" (*Engineering News*, February 18, 1917). We possess very little information about the processes and procedures of urban maintenance, aside from a belief, as the quotation illustrates, that it was done badly. There is a folklore that political machines did a very poor job in maintenance while reform governments did a superior job. This hypothesis, while possibly true, has never been fully tested.
- The influence of neighborhoods on infrastructure development: There is some evidence that the "revolt of the neighborhoods" is not just a phenomenon of the 1970s and that neighborhoods exercised influence over infrastructure decisions in their areas as early as the nineteenth century. We need to develop more information concerning how neighborhood groups as opposed to politicians or real estate developers shaped the process of infrastructure development, and what forms of governments appeared more sensitive to their preferences.
- Comparisons between types of cities with regard to infrastructure development: We are just beginning to study the development

of public works in specific cities over time. While these examinations are useful, we are in need of comparative studies that isolate such variables as the timing of innovation, the age of a city, political forms, economic development, and demographic characteristics. The one study that attempts this, while useful, is limited to smaller cities in a specific region (Hollingsworth and Hollingsworth, 1979).

- The diffusion process: Aside from nineteenth-century water supply systems, we know little about the process by which urban technologies and innovations were diffused among the network of cities over time. We need more information on the relationship of diffusion to factors such as the employment of individuals, engineering and consulting firms, professional associations, industrial marketing activities, and communications networks.
- The development of standards and codes: Standards and codes appear to have played a large role in shaping the development of the infrastructure and the process of innovation, but we know very little about the influences involved in their development and how they affected the process of change. We need studies to show where adherence to codes and standards has blocked innovation and also about the process by which, if at all, they were altered or changed.
- The development and experience of different funding mechanisms for urban infrastructure.

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BIBLIOGRAPHY

Abbott, Carl
1981 *The New Urban America: Growth and Politics in Sunbelt Cities*. Chapel Hill: The University of North Carolina Press.

Aldrich, Mark
1980 A history of public works in the United States, 1790-1970. In CONSAD, *A Study of Public Works Investment in the United States*. Available from the U.S. Government Printing Office. Washington, D.C.: U.S. Department of Commerce.

Altshuler, Alan, with James P. Womack and John R. Pucher
1979 *The Urban Transportation System: Politics and Policy Innovation*. Cambridge, Mass.: MIT Press.

American Public Works Association
1981 *Revenue Shortfall: The Public Works Challenge of the 1980's.* Chicago: American Public Works Association.

American Society of Civil Engineers
1972 *A Biographical Dictionary of American Civil Engineers.* New York: American Society of Civil Engineers Historical Publication.

Anderson, Alan
1977 *The Origin and Resolution of an Urban Crisis: Baltimore, 1890-1930.* Baltimore: Johns Hopkins University Press.

Anderson, Letty Donaldson
1980 The Diffusion of Technology in the Nineteenth Century American City: Municipal Water Supply Investments. Unpublished Ph.D. dissertation, Northwestern University.

Armstrong, Ellis L., Robinson, Michael C., and Hoy, Suellen M., eds.
1976 *History of Public Works in the United States 1776-1976.* Chicago: American Public Works Association.

Arnold, Joseph
1979 The neighborhood and City Hall: the origin of the neighborhood associations in Baltimore, 1880-1911. *Journal of Urban History* 6(Nov.):3-30.

Baker, M. N.
1896 *Sewerage and Sewage Purification.* New York: Engineering News Publishing Co.

Berry, Brian J. L.
1981 *Comparative Urbanization: Divergent Paths in the Twentieth Century.* New York: St. Martin's Press.

Blake, Nelson Manfred
1956 *Water for the Cities: A History of the Urban Water Supply Problem in the United States.* Syracuse: Syracuse University Press.

Booth, Douglas E.
1983 Transportation, city building, and financial crisis: Milwaukee, 1852-1868. *Journal of Urban History* 9(3):335-363.

Brownell, Blaine A.
1975 *The Urban Ethos in the South 1920-1930.* Baton Rouge: Louisiana State University Press.

Bruchey, Stuart
1965 *The Roots of American Economic Growth, 1607-1861.* New York: Harper & Row.

Bureau of the Census
1975 *Historical Statistics of the United States: Colonial Times to 1970.* Available from the U.S. Government Printing Office. Washington, D.C.: U.S. Department of Commerce.

Calhoun, Daniel Hovey
1960 *The American Civil Engineer: Origins and Conflict.* Cambridge, Mass.: MIT Press.

Caro, Robert
1974 *The Power Broker: Robert Moses and the Fall of New York.* New York: Vintage Books.

Carter, Edward, C., II
1975 The engineer as agent of technological transfer: the American career of Benjamin Henry Latrobe. In Barbara Genson, ed., Benjamin Henry Latrobe and Moncure Robinson: *The Engineer as Agent of Technological Transfer.*

1976 *Benjamin Henry Latrobe and Public Works: Professionalism, Private Interest, and Public Policy in the Age of Jefferson.* Essays in Public Works History No. 3. Washington, D.C.: Public Works Historical Society.

Cheape, Charles

1980 *Moving the Masses: Urban Public Transit in New York, Boston, and Philadelphia, 1880-1912.* Cambridge, Mass.: Harvard University Press.

Choate, Pat, and Walter, Susan

1981 *America in Ruins: Beyond the Public Works Pork Barrel.* Washington, D.C.: Council of State Planning Agencies.

Condit, Carl W.

1973 *Chicago 1910-1929: Building, Planning and Urban Technology.* Chicago: University of Chicago Press.

CONSAD

1980 *A Study of Public Works Investment in the United States, Vol. 1: Historical Analysis of PWI Trends and Financing Mechanisms.* Available from the U.S. Government Printing Office. Washington, D.C.: U.S. Department of Commerce.

Daniels, Roger

1975 *The Relevancy of Public Works History: The 1930's—A Case Study.* Washington, D.C.: Public Works Historical Society.

Dorsett, Lyle W.

1977 *Franklin D. Roosevelt and the City Bosses.* Port Washington, N.Y.: Kennikat Press.

Duffy, John

1974 *A History of Public Health in New York City 1866-1966.* New York: Russell Sage Foundation.

Dunn, Edgar S., Jr.

1980 *The Development of the U.S. Urban System.* Baltimore: Johns Hopkins University Press.

Ellis, John H.

1970 Businessmen and public health in the urban South during the nineteenth century: New Orleans, Memphis, and Atlanta. *Bulletin of the History of Medicine* 44(May/June, July/Aug.):197-212, 346-371.

Fisher, Edwin A.

1933 Engineering and public works in the city of Rochester. In Edward R. Foreman, ed., *Centennial History of Rochester, New York. Vol. III.: Expansion.* Rochester, N.Y.: Rochester Public Library.

Fitch, James Marston

1966 *American Building I: The Historical Forces That Shaped It.* Boston: Houghton Mifflin.

Fogelson, Robert M.

1967 *The Fragmented Metropolis: Los Angeles 1850-1930.* Cambridge, Mass.: Harvard University Press.

Fosler, R. Scott, and Berger, Renee A., eds.

1982 *Public-Private Partnership in American Cities: Seven Case Studies.* Lexington, Mass.: Lexington Books.

Foster, Mark S.

1981 *From Streetcar to Superhighway: American City Planners and Urban Transportation 1900-1940.* Philadelphia: Temple University Press.

Fox, Kenneth

1977 *Better City Government: Innovation in American Urban Politics, 1850-1937.* Philadelphia: Temple University Press.

Frisch, Michael H.
1972 *Town Into City: Springfield, Massachusetts and the Meaning of Community, 1840-1880.* Cambridge, Mass.: Harvard University Press.
Galishoff, Stuart
1980 Triumph and failures: the American response to the urban water supply problem, 1860-1923. In Martin V. Melosi, ed., *Pollution and Reform in American Cities, 1870-1930.* Austin, Texas: University of Texas Press.
Gelfand, Mark I.
1975 *A Nation of Cities: The Federal Government and Urban America 1933-1965.* New York: Oxford.
Genson, Barbara E., ed.
1975 *Benjamin Henry Latrobe and Moncure Robinson: The Engineer as Agent of Technological Transfer.* Wilmington, Del.: Eleutherian Mills Historical Library.
Gere, Edwin A., Jr.
1982 Dillon's rule and the Cooley doctrine: reflections of the political culture. *Journal of Urban History* 8(May):271-298.
Glaab, Charles N.
1968 Metropolis and suburb: the changing American city. In John Braeman et al., eds., *Change and Continuity in Twentieth-Century America: The 1920's.* Columbus: Ohio State University Press.
Gluck, Peter R., and Meister, Richard J.
1979 *Cities in Transition: Social Changes and Institutional Responses in Urban Development.* New York: New Viewpoints.
Goldfield, David R., and Brownell, Blaine A.
1979 *Urban America: From Downtown to No Town.* Boston: Houghton Mifflin Co.
Gottlieb, Manuel
1976 *Long Swings in Urban Development.* New York: National Bureau of Economic Research. (Distributed by Columbia University Press.)
Griffith, Ernest S.
1974 *The Conspicuous Failure: A History of American City Government 1870-1900.* New York: Praeger.
Harris, Carl V.
1977 *Political Power in Birmingham, 1871-1921.* Knoxville: The University of Tennessee Press.
Hawkins, Robert B., Jr.
1976a *Self-Government by District: Myth or Reality.* Stanford, Calif.: Hoover Institute Press.
1976b Special districts and urban services. In Elinor Ostrom, ed., *The Delivery of Urban Services.* Beverly Hills: Sage Publications.
Hays, Samuel P.
1974 The changing political structure of the city in industrial America. *Journal of Urban History* 1(Nov.):6-38.
Hillhouse, Albert M.
1935 Lessons from previous eras of defaults. In A. Chatters, ed., *Municipal Defaults: Their Prevention and Adjustment.* Publication No. 33. Chicago: Municipal Finance Officers Association.
1936 *Municipal Bonds: A Century of Experience.* New York: Prentice-Hall.
Hollingsworth, J. Rogers, and Hollingsworth, Ellen Jane
1979 *Dimensions in Urban History.* Madison: University of Wisconsin Press.

Holt, Michael Fitzgibbon
1969 *Forging a Majority: The Formation of the Republican Party in Pittsburgh, 1848-1860.* New Haven: Yale University Press.
Hoy, Suellen M., and Robinson, Michael C., comps.
1982 *Public Works History in the United States: A Guide to the Literature.* Nashville, Tenn.: American Association for State and Local History.
Jackson, Joy J.
1969 *New Orleans in the Gilded Age: Politics and Urban Progress 1880-1896.* Baton Rouge: Louisiana State University Press.
Jackson, Kenneth T.
1975 Urban deconcentration in the nineteenth century: a statistical inquiry. In Leo F. Schnore, ed., *The New Urban History: Quantitative Explorations by American Historians.* Princeton, N.J.: Princeton University Press.
Kahrl, William L.
1982 *Water and Power.* Berkeley: University of California Press.
Kirkland, Edward C.
1961 *Industry Comes of Age: Business, Labor, and Public Policy 1860-1897.* New York: Holt, Rinehart and Winston.
Lane, Roger
1967 *Policing the City: Boston 1822-1885.* Cambridge, Mass.: Harvard University Press.
Layton, Edward
1971 *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession.* Cleveland, Ohio: Case Western Reserve University Press.
Leavitt, Judith Walzer
1982 *The Healthiest City: Milwaukee and the Politics of Health Reform.* Princeton, N.J.: Princeton University Press.
Lively, Robert A.
1955 The American system: a review article. *Business History Review* 24(Summer):81-95.
Martin, Richard J. L., and Willeke, Gene E.
1978 *The House That Jack Built: An Agenda for the Assessment of the Technologies of the Built Environment.* Atlanta: Georgia Institute of Technology, School of Architecture.
McShane, Clay
1974 *Technology and Reform.* Madison: The State Historical Society of Wisconsin.
1979 Transforming the use of urban space: a look at the revolution in street pavements, 1880-1924. *Journal of Urban History* 5(May):279-307.
Merritt, Raymond H.
1969 *Engineering in American Society.* Lexington: University Press of Kentucky.
Moehring, Eugene P.
1981 *Public Works and the Patterns of Urban Real Estate Growth in Manhattan, 1835-1894.* New York: Arno Press.
1982 *Public Works and Urban History: Recent Trends and New Directions, Essays in Public History.* No. 13. Chicago: Public Works Historical Society.
Moore, Peter W.
1983 Public services and residential development in a Toronto neighborhood 1880-1915. *Journal of Urban History* 9(Aug.):445-471.
Muller, Peter O.
1981 *Contemporary Suburban America.* Englewood Cliffs, N.J.: Prentice-Hall.

Office of Technology Assessment
1981 *Technology for Local Development.* Washington, D.C.: U.S. Government Printing Office.

Olson, Sherry H.
1980 *Baltimore: The Building of an American City.* Baltimore: Johns Hopkins University Press.

Peterson, Jon A.
1976 The City Beautiful movement: forgotten origins and lost meaning. *Journal of Urban History* 2(Aug.):415-434.
1979 The impact of sanitary reform upon American urban planning, 1840-1890. *Journal of Social History* 13(Fall):83-104.

Platt, Harold L.
1975 Urban Public Services, 1873-1914: A Reconsideration of Social and Structural Reform. Unpublished paper, Loyola University of Chicago.
1983 *City Building in the New South: The Growth of Public Services in Houston, Texas, 1830-1915.* Philadelphia: Temple University Press.

Pred, Allan R.
1966 *The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800-1914.* Cambridge, Mass.: MIT Press.

Rae, John B.
1971 *The Road and the Car in American Life.* Cambridge, Mass.: MIT Press.

Rose, Mark H.
1979 *Interstate: Express Highway Politics, 1941-1956.* Lawrence, Kansas: Regents Press.

Rose, Mark H., and Clark, John G.
1979 Light, heat, and power: energy choices in Kansas City, Wichita, and Denver, 1900-1935. *Journal of Urban History* 5(May):340-364.

Rosenberg, Nathan
1972 *Technology and American Economic Growth.* White Plains, N.Y.: M. E. Sharpe.

Schiesl, Martin J.
1977 *The Politics of Efficiency: Municipal Administration and Reform in America: 1880-1920.* Berkeley: University of California Press.

Schultz, Stanley K., and McShane, Clay
1978 To engineer the metropolis: sewers, sanitation and city planning in late-nineteenth century America. *Journal of American History* 65(Sept.):389-411.

Seely, Bruce E.
1982 Engineers and Government-Business Cooperation: Highway Standards and the Bureau of Public Roads, 1900-1940. Unpublished manuscript, Texas A&M University.

Simon, Roger D.
1978 *The City-Building Process: Housing and Services in New Milwaukee Neighborhoods 1880-1910.* Philadelphia: American Philosophical Society.

Stearns, Peter N., and Tarr, Joel A.
1982 Applied history: new/old frontier for the historical discipline. *Institute News* 3(Oct.).

Stewman, Shelby, and Tarr, Joel A.
1982 Four decades of public-private partnerships in Pittsburgh. In R. Scott Fosler and Renee A. Berger, eds., *Public-Private Partnership in American Cities: Seven Case Studies.* Lexington, Mass.: Lexington Books.

Studenski, Paul
1930 *The Government of Metropolitan Areas in the United States.* New York: National Municipal League.

Studenski, Paul, and Krooss, Herman E.
1952 *Financial History of the United States.* New York: McGraw-Hill.

Tarr, Joel A.
1971 The urban politician as entrepreneur. In Bruce Stave, ed., *Urban Bosses, Machines, and Progressive Reformers.* Boston.
1973 From city to suburb: the moral implications of transportation technology. In Alexander Callow, ed., *American Urban History.* Rev. ed. New York: Oxford.
1978 *Transportation Innovation and Changing Spatial Patterns in Pittsburgh, 1850-1934.* Essays in Public Works History, No. 6. Chicago: Public Works Historical Society.
1979 The separate vs. combined sewer problem: a case study in urban technology design choice. *Journal of Urban History* 5(May):308-339.

Tarr, Joel A., and McMichael, Francis C.
1977 The evolution of wastewater technology and the development of state regulation: a retrospective analysis. In Joel A. Tarr, ed., *Retrospective Technology Assessment.* San Francisco: San Francisco Press.

Tarr, Joel A., McCurley, James, and Yosie, Terry F.
1980 The development and impact of urban wastewater technology: changing concepts of water quality control, 1850-1930. In Martin V. Melosi, ed., *Pollution and Reform in American Cities.* Austin: Texas University Press.

Tarr, Joel A., et al.
1978 *Retrospective Assessment of Wastewater Technology in the U.S., 1850-1972.* Report to the National Science Foundation. Available from the National Technical Information Service, Springfield, Va.

Taylor, George Rogers
1966 The beginnings of mass transportation in urban America. *The Smithsonian Journal of History* (Summer, Autumn):35-50; 31-54.

Teaford, Jon C.
1975 *The Municipal Revolution in America: Origins of Modern Urban Government, 1650-1825.* Chicago: University of Chicago Press.
1979 *City and Suburb: The Political Fragmentation of Metropolitan America, 1850-1970.* Baltimore: Johns Hopkins University Press.
1982 Finis for Tweed and Steffens: rewriting the history of urban rule. *Reviews in American History* (December):137-139.

Wade, Richard C.
1959 *The Urban Frontier: The Rise of Western Cities, 1790-1830.* Cambridge, Mass.: Harvard University Press.

Ward, David
1971 *Cities and Immigrants: A Geography of Change in Nineteenth Century America.* New York: Oxford.

Warner, Sam Bass, Jr.
1962 *Streetcar Suburbs: The Process of Growth in Boston, 1870-1900.* Cambridge, Mass.: Harvard University Press and MIT Press.
1968 *The Private City: Philadelphia in Three Periods of Its Growth.* Philadelphia: University of Pennsylvania Press.

Weingold, Marilyn
1980 *Pioneering in Parks and Parkways: Westchester County, New York, 1895-1945.* Essays in Public Works History, No. 9. Chicago: Public Works Historical Society.
Wiebe, Robert H.
1967 *The Search for Order, 1877-1920.* New York: Hill and Wang.

DISCUSSION

Randy Hamilton

A historical view of urban public facilities should focus on tools, skills, materials, and sources of power. These themes allow cohesion in analysis.

In discussing the financing of infrastructure, we should perhaps say that cities invested rather than spent; the returns on this investment have been great. Compared with private investments, defaults have been rare. This is a remarkably good performance. In analyzing the financing of urban facilities, it would also be helpful to place some of the numbers in perspective, comparing them with total city budgets.

Having looked at the walking city, the transit city, and the automobile city, we now need to speculate on the next kind of city, perhaps the "wired" city, and the changes in infrastructure it will require.

Finally, we should give some attention to how we train public works professionals.

Wilfred Owen

Tarr's analysis suggests ways in which history repeats itself. It also identifies some things we should not allow history to repeat. The major issue raised by tracing urban evolution is the kind of city that comes next: the space-age city—the city concerned with both inner and outer space.

We have moved in a short time from cesspools and cisterns to microcomputers, lasers, and fiber optics as important elements of urban infrastructure. These new technologies will make vast differences in the character and functions of urban America and produce, in turn, revolutionary changes in supporting infrastructure.

Two principal conclusions can be drawn:

1. We should be alert to history to anticipate but not simply to accept changes, to understand and influence them in the national interest.
2. Just as history can be a guide, so can geography. We frequently ignore both.

One impressive fact in our public works history is how much we learned from Europe in the early days. Its experts were welcomed to our cities. Any current research program should emphasize technology transfer, combining our awareness of history with more careful analysis of infrastructure solutions in other parts of the world. There is too little comparative analysis. This is important in several respects, particularly in the development of large cities and in the organization of the suburbs. Large urban areas are the culmination of complex approaches to urban development. Some countries are beginning to use large transportation systems to organize such large-scale development. Japan, for instance, connects major urban concentrations by high-speed rail lines. Singapore has redeveloped itself and a series of major satellites and in the process has achieved a high standard of living. We need a much better understanding of how these places have developed and the role of their public works systems in how they took shape and how they function as cities.

Tarr's paper reminds us that our legacy of public works stays with us. The depression-era facilities and those of more recent years remain a most important part of today's infrastructure. They provide some important lessons for us, such as the need to include in the design the people for whom they are built.

Concerning the pitfalls and possibilities of borrowing, some of the most exciting projects in the world are being financed by development banks, such as the World Bank and the Inter American Development Bank. These banks guarantee loans made by private bankers. We should have an internal U.S. development bank to undertake needed projects at home.

Another lesson from history concerns pricing. Our rates for using facilities have often been too low, whether for transit, commuter railroads, or water systems. We have consistently underpriced the highway system. It is now clear that we must not only pay to build these systems, but we must also have an assured means of sup-

porting their operation. Some financial trade-offs are necessary and are being made. Of the 21 cents a mile it costs to drive a compact car, for instance, only 1 cent supports the highway system. We need to ask how we can make more energy-efficient vehicles and use the savings in design and operating costs to pay for the facilities they must use. Both pricing and regulations can reduce costs and demand. The restriction of the extension of Route I-66, in the Virginia suburbs of Washington, to high-occupancy vehicles during rush hours is an illustration of the use of regulation to influence demand.

History and geography suggest a strategy for future research and action that combines technology, large systems, jobs, and new methods of finance to determine the need for a national city-building effort. City-building corporations using modern technology and engineering might be created for both new development and redevelopment involving a joint public and private effort. This approach would be better for the country, producing more efficient and satisfying cities instead of stagnation and decay. This of course depends on careful analysis of situations and what might be done better.

Abel Wolman

Tarr provides us with a comprehensive clinical diagnosis of the evolution of public works service to U.S. society. The record is a rehearsal of ad hoc responsiveness to the demands of people, often incoherent, for protection against fire, dirt, disease, and immobility.

His detailed account of these efforts makes clear that the evolution of infrastructure to provide service is "more complex than simple economic models suggest." The progress was cyclical in nature, reflecting economic depressions and recovery, the rise and fall of "bossism," temporary reformism, and political ideology. Physical obstacles to trade demanded correctives, which are described by Tarr in colorful designations of the transition from the walking city, to the streetcar city, to the automobile city, and, I might add without plagiarizing, to the subway city.

For two centuries, contests and changes were marked by the forces of public and private groups and governmental and voluntary pressures. If there is a common thread of deliberate reasoning and plan throughout these years of true progress and failures, it is that the movement was essentially forward. The search for the motivating grand plan was and still is elusive.

What are the implications for the present and the future of this

past record of human endeavor? Tarr suggests five or six areas for future research. All of them are significant markers to aid the future worker in this field of high social impact. But they are too limited.

I venture to suggest some additional therapies, largely reflective of a lifetime of participation in and observation of the functions here discussed. I am startled by the fact that my own span of life covers almost half the period Tarr has so vividly traversed. My view is colored by activities as a public official at all three levels of government, as an educator, and as a consultant.

Some preliminary observations provide a setting. Accomplishments by reformers have been episodic and of short duration. One of their lauded gifts was in civil service protection, a device I have found less than helpful. Too often, it too has succumbed to corruption and has resulted in constraint of personnel change and in protection of mediocrity. As to "bossism," one of our most progressive and efficient mayors once nostalgically remarked that the old-time boss provided more effective municipal service than modern checks and balances have produced! The suggestion has much relevance to our view of present policy making.

We live now in a stressful and exciting arena, reminiscent of a few earlier situations. The compound of an economic recession, coupled with a new set of ideologies regarding government intervention, drives us toward new orientations in public works development. While we rush toward correctives of the so-called welfare state objectives of the 1930s Roosevelt programs, we are engaged in again battling over work programs characteristic of those same bygone days.

The New Federalism is a revival of the proposals of Franklin Roosevelt and Dwight Eisenhower. Simultaneously, environmental groups press toward negativism. Public participation engenders multiple pressure groups at all levels of governmental decision making.

On this stage, old and new solutions press for prompt study, evaluation, and implementation, and I add a few here.

1. What are the potentialities for survival of the weakened cities? Will they continue to lose people and viability?
2. May cities be joint beneficiaries of wider-area taxes and corresponding services?
3. Increasing private corporate responsibility for many public works is illustrated in water supply, sewerage, solid wastes,

bridges, and even schools. What protective measures are indicated for the revival of these old contests?

4. New institutional structures, transcending political boundaries, would be helpful. Political scientists have advocated these for more than half a century. Can their delayed use be expedited?
5. Are municipalities really bankrupt? Or do we mean their governments are, as distinct from their constituents?
6. Municipalities have a long and successful history of local autonomy and responsibility. These have been seriously eroded by federal largesse and consequent transfer of decision making to federal agencies. How best may responsibility be recaptured in a disappearing long-time flood of federal and state money?
7. Financing local public works has likewise a long record of success. In a period of economic disability, orthodox formulas appear less available. What innovations in local fiscal policy are discernible or developable? Fortunately, serious approaches to new potentials of financing are being explored.
8. Delayed maintenance and operation have resulted in the widespread deterioration of systems. The reasons for the imminent collapse are not hard to find. More glamorous objectives have held the stage over the past decades, and it has been easy to cut budgets in less conspicuous, but life-supporting, necessities. Must one wait to avoid catastrophe for billions of dollars from nonexistent sources? Some public works directors have already moved forward in determining priorities, planning correctives, and engaging in the "doable." What feasible implementations are discernible, while waiting for a new millennium of federal largesse?
9. The advent of public participation is not new. Its extent and militancy today are greater. What devices may be developed to provide an early shift from adversarial to mediated resolution of highly important public issues? No formula is readily at hand.

Underlying all I have said is an issue of far broader implications than for infrastructure alone. The participation of the public has undoubtedly always been essential. In recent years its elaboration has been stimulated in no small degree by officialdom. The flowering of pressure groups, including many of our own professions, has resulted in some input of value. On the debit side, the phenom-

enon has eroded the democratic process, wherein decision making was once assigned to elected officials. Aided and abetted by public polls, not distinguished by clear neutrality, the elected official keeps an eye on the polls and on television. Pressure groups provide an important source of information and ideas. They are often in conflict and only infrequently do their desires result in sound public interest decisions. More important, they are not responsible for the socio-economic results of their implemented demands. This broader question of public policy making deserves a place on our agenda for research.

I do not pretend that these opportunities for research exhaust the list. They are illustrative of present challenges in public works development. Inherent in them is an assumption that the day of new works and rehabilitation of the old is not over. People multiply, and their demands are rarely reduced. Tens of millions wait for water supply, sewerage, solid wastes handling, transport, safety, and health. The desires are not new. While we search for innovation, the record is clear that the past discloses many markers for the future. For this disclosure, I am forever indebted to the diligence of Joel Tarr.

SUMMARY

In theory perhaps some cities should be allowed to die, but there is a human factor involved. The important question is: What options are available for a city? We know from history that it is hard to establish a rigid framework for such analysis. Politics, value changes, and the rise of professionalism have all altered the course of events.

We know that cities will become more communications-intensive, but people will still expect water from the tap. We will still need streets and sewers. Thus, while some demands on facilities will change and there may be new types of facilities, some traditional parts of the infrastructure will remain important.

The distinctions between the use of public works for immediate job creation and long-term investments were much clearer during the New Deal period than they are today. Our dilemma is that our cities are in a state of flux. It is not clear what will happen to older cities. Incidentally, some of those thought to be dying in the 1930s are back on the table for observation today. Their original reasons for existence have disappeared; the question is whether they can find a new reason. In this sense it is hard to approach spending for

public works by arguing that all that is needed is to take old plans off the shelf and start building. Those plans often do not lend themselves to current needs.

We really have not wrestled with the decision-making process. We need to look hard at bosses versus professionals versus public participation in public works decisions. This issue should be examined in terms of how we should set priorities and who should be involved. We need to look at the contradictory benefits of each system. The federal decision to put the interstate system through cities instead of stopping at the beltways, for instance, was a critical one that preempted other local choices. Federal mandates may cause more problems than they are worth.

One federal official argued that local politicians will not focus on the size and scope of infrastructure problems because of their responsiveness to political pressure. He suggested that government could not be trusted to solve the problem and that the problem of conflicting pressures could be resolved only if the private sector takes more responsibility. This view was strongly contested; another participant argued that the private sector would simply make decisions that were in its own interest. The point was also made that the political system was indeed responsive to its constituents, in contrast with dealing with an abstract, normative model of what "should" be done.

2

Assessing Infrastructure Needs: The State of the Art

D. Kelly O'Day and Lance A. Neumann

INTRODUCTION

The Infrastructure Problem

There is a growing impression that America's basic public facilities—its highways, bridges, and water and sewer systems—are badly deteriorated. The national press, trade associations, and now the general public are concerned that these basic systems are in danger of collapse. Each new public works problem is taken as additional proof of the pending crisis facing the urban infrastructure.

The widespread concern about the condition of the nation's public facilities stems primarily from two sources: the obvious deterioration of highly visible facilities like interstate highways and the fact that both capital and maintenance spending on public infrastructure has been reduced in constant dollars in the past decade. Public works capital investment as a portion of the gross national product has dropped from 4.1 percent in 1965 to 2.3 percent in 1977. Many state and local governments, faced with pressing budget problems, have been forced to reduce capital rehabilitation as well as operating and maintenance budgets for public facilities. A 1981 survey by the American Public Works Association indicates that noncapital public works budgets were reduced during the 1970s, if the

effects of inflation are considered. The average relative decrease in the 1970-1976 period was 0.18 and 0.66 percent per year for U.S. cities and counties, respectively. The comparable decreases for the 1977-1979 period were 0.44 and 1.55 percent per year. This means that public works operation and maintenance budgets, in constant dollars, were decreasing at an accelerating rate during the 1970s.

This trend of declining capital and maintenance budgets raises serious concern about the future condition of public facilities; maintenance cutbacks are bound to shorten the useful life of facilities at a time when capital rehabilitation funds are limited. At every level of government, elected officials and public works administrators are raising questions about the existing and likely future condition of public facilities.

The heightened awareness of a potential infrastructure crisis has spawned a host of so-called needs studies that have attempted to define the magnitude of the problem ahead in dollar terms. To date these efforts have not created a comprehensive data base or conditions assessment, particularly for county and municipal facility systems. Rather, these studies, based on a variety of methods and assumptions, have focused on particular elements of the infrastructure system.

While a precise definition of the problem has eluded us, in some areas (particularly highways, bridges, and transit), additional funds are being made available and the rate of system rehabilitation will be increased. Additional needs studies will be conducted (the recently passed federal transportation act calls for a $3 million national infrastructure needs study) to further define the problem. Our purpose in this paper is to examine how these additional needs studies can best be used to guide decisions on both the level of investment appropriate for an infrastructure system and the allocation of available resources to specific facility improvements and maintenance strategies.

National Needs

What are the nation's infrastructure needs? Accurate and reliable cost estimates are not available, but various investigators have developed projected needs based on limited data. Table 2-1 summarizes a variety of national estimates of capital expenditure needs for the next 15 years. These estimates represent $2.5-3.0 trillion, a staggering amount of money, equivalent to the 1979 gross na-

TABLE 2-1 National Infrastructure Needs, 1982-1997

Sector	Cost ($ billions)
Nonfederal-aid highway	1,000
Federal-aid highway	200-225
Bridges	50
Water supply	
urban	100-150
rural	45
Wastewater treatment	75-100
Mass transit	80
Jails	8
Other[a]	1,000
TOTAL	2,478-2,578

[a]Includes dams, water storage, ports, community buildings, city halls, and recreational facilities.

SOURCE: Rochelle Stanfield, *National Journal*, November 27, 1982.

tional product of the United States. Viewed in another way, these costs represent 10 times the estimated total construction activity of the country in 1983, including all public, private, and residential construction. The total nonresidential construction in 1982 was $94.2 billion; the infrastructure-related construction was $25.1 billion, 27 percent of all nonresidential construction or slightly less than 10 percent of all construction.

These needs estimates are clearly beyond the country's capabilities, raising the question as to whether they are really necessary or represent a "wish list" of projects. Even assuming there is some legitimacy to such overwhelming needs estimates, a critical issue that must be addressed is the degree of priority of different needs within a sector and the appropriate balance in addressing needs in different sectors.

The Challenge Ahead

There can be little question that the country will face some serious public infrastructure problems in the next decade and beyond. However, there remain some nagging questions about how serious the problem really is and what level of investment is required to address it. While elected officials seem increasingly willing to devote additional resources to rehabilitate selected public facilities, they often have not been armed with the type and quality of information that ought to be a basis for such critical choices. To fill this information

gap, professionals will have to address questions such as:

- Has the quality of facility inventory and conditions assessments been adequate to identify deficiencies in a consistent and precise manner?
- Have recent national needs estimates been worth the effort, given the basic methods and assumptions used?
- Is it useful to divorce needs studies from a broader investment planning process that ultimately is required to allocate resources to specific improvements?

Addressing these questions may lead to the conclusion that improved approaches to defining infrastructure needs and estimating required levels of investment are but two steps in restructuring and improving the management of public facilities. While there are many deserving needs that should be met, the challenge confronting this symposium and others like it is to ensure that whatever resources can be made available are managed and used in as cost-effective a manner as possible. This will require moving beyond arbitrary definitions of need and design standards to a much more creative approach to public works management.

DEFINING NEEDS

Needs Versus Desirable Improvements

A critical issue involved in defining infrastructure needs is communicating a realistic sense of the urgency of responding to various levels of need and the consequence of ignoring, or postponing a response to, any unmet needs. Decision makers need to know the real impacts of varying levels of infrastructure investment before they can make meaningful judgments about the appropriate level of resources to devote to the very real and serious problems confronting the nation's public investment priorities. In short, for a definition of capital needs to be useful it must describe more than the total dollars required in a particular sector over some long time period.

Unfortunately, the approach taken to defining need in many studies has been, and continues to be, very narrow and of limited usefulness in guiding resource allocation decisions at any level of government. In a recent speech focusing on the desirability of a national capital budget, Senator Tsongas (D-Massachusetts) noted that Con-

gress cannot deal with needs estimates ranging from hundreds of billions to tens of trillions of dollars for the highway system. When confronted with such ranges, the needs estimates become almost irrelevant.

Needs defined in this traditional manner have referred to the level of investment required to either complete construction of a new system or to bring existing facilities up to some prespecified standard. While the standard or standards chosen often include physical condition and design criteria as well as level of service and demand-related criteria, most needs studies have been based on unstated assumptions about economic, social, and environmental objectives, performance standards, and growth trends. These standards themselves, as well as the ability to clearly relate infrastructure investment and performance levels to broader objectives, particularly economic objectives, are being questioned.

The result of the traditional needs approach generally has been estimates of capital investment requirements far in excess of available resources or even the most optimistic projections of new revenue sources. As a result, many needs studies have been viewed as self-serving and lacking any real credibility. Long-range needs estimates, in the abstract and independent of short-range budget decisions, are difficult to understand and often are not very useful. Ultimately, tough priority decisions have to be made about how to spend available resources, and too often needs studies have provided no real guidance on how to separate desirable improvements from critically important investments required to maintain essential service levels.

It is this lack of differentiation between various levels or priority of needs that has severely limited many past needs studies. Undue emphasis has been placed on coming up with a total dollar amount without careful analysis of the underlying assumptions or the effectiveness of providing varying levels of investment.

One factor that has led to an overly narrow definition of needs is the view that needs studies are primarily a vehicle to lobby for additional funds. Of course, demonstrating a level of need and justifying particular funding levels is a necessary and important part of the capital investment planning process. However, almost any program can demonstrate a large backlog of unmet and deserving needs. While one approach is to develop needs lists or wish lists for each sector requiring capital investments and hope that decision makers guess well, a sound capital investment strategy is unlikely

to result from such a process. This is particularly true at the state and local levels, where decisions concerning specific individual facilities must ultimately be made.

Alternatively, needs studies can be redefined to relate potential investment levels more explicitly to system performance and provide a clearer sense of the importance of satisfying different levels of investment need. Needs defined in this way will not be absolute or particularly amenable to naive characterization by one total dollar level. Nonetheless, a broader definition of need and more effort devoted to differentiating the importance of meeting different needs will provide a more effective basis for decisions on both the appropriate level of capital investment and the most cost-effective allocation of any given amount of available resources.

The Needs Assessment Process

The two key activities in the needs assessment process are:

- inventory and conditions assessment of existing facilities both currently and in light of estimates of future usage and
- identification of the desired level or levels of maintenance and improvement.

Development of a new and broader needs assessment process and a more useful definition of needs requires a careful analysis of the appropriate approaches to both these activities.

The inventory and conditions assessment of existing facilities is a relatively straightforward and value-free task in theory. In practice, however, given the enormity of the job for some public infrastructure systems, a wide range of approaches has been taken for getting some estimate of current conditions. To the extent that the inventory and conditions assessment is a detailed facility-by-facility appraisal by trained professionals based on sound engineering data and measurements, debate over the current condition and projected future condition of facilities can be minimized. However, when the conditions assessment is based on a sample of facilities, performed by relatively inexperienced staff or performed using very crude assumptions and measures of conditions, questions about the real condition of a particular system will frustrate any attempt to define the capital investment needed to maintain or improve the system.

Again, it is recognized that needs studies conducted at different levels of government are often satisfying different objectives and

must rely on different analysis approaches. Our primary concern is viewing needs studies from the perspective of state and local governments that ultimately have operating responsibility for maintaining urban infrastructure.

There have been many attempts to define highway conditions (and ultimately investment needs) based on a small sample of road segments. A recent study of all rural public facilities was based on a survey of a very few local officials in a very large number of rural communities rather than a very detailed study of actual facility conditions in a much smaller number of communities. Although such approaches may serve some limited objectives at the federal level for getting an idea of how bad the problem might be, they may not provide a very sound basis for determining appropriate capital investment levels and strategies. Ultimately, good investment decisions generally will require a detailed appraisal of each facility compared with overall system conditions, and it would be much better for any serious needs assessment process to start with such an appraisal. While not perfect, the national bridge inventory and inspection program offers an example of an attempt to provide a comprehensive and sound facility conditions data base as a foundation for judging the nation's bridge needs.

The critical components of an inventory and conditions assessment process should be:

- an overall description of the system (location, physical description, capacity, etc.);
- structural integrity;
- the quality of service and level of usage;
- safety; and
- the role of each facility in the overall system (i.e., some functional classification).

While the specific data and criteria that are appropriate will vary widely depending on the type of system (highway, water distribution, sewer, etc.) being examined, detailed and specific information on the items identified above will be critical both to define meaningful investment needs and to maintain, improve, and manage the system over time, irrespective of the level of resources allocated.

Once an inventory and a conditions assessment of existing facilities have been completed, the appropriate level or levels of maintenance and improvement can be determined once assumptions about future usage and facility conditions have been made. As described

earlier, this element of the needs process has often been accomplished in an extremely mechanical way by comparing each facility to a prespecified set of standards and simply defining needs as the cost of bringing each facility up to standards. While such an approach has an attractive simplicity to it, the results in general will not provide a good basis for determining the appropriate level of investment and how to allocate funds among various facilities.

The appropriate level of investment in any component of public infrastructure will depend on the effectiveness of a particular investment level in meeting a variety of economic and social objectives compared with investments in other infrastructure systems or other programs. While measuring the effectiveness of public investments has always been difficult, some measures of effectiveness and output can be defined for each infrastructure system. Explicitly relating investment to output, however defined, will almost always be preferable to assuming that a set of design standards can serve as an adequate proxy. Some studies are already moving in this direction. For example, federal highway needs studies that have been conducted periodically since the late 1960s have increasingly stressed performance criteria and the monitoring of system conditions. In fact, a soon-to-be-released federal highway performance study will include an analysis of the economic impacts of highway improvements and systems performance. However, further steps can be taken to evaluate the real effectiveness of varying levels of highway investment, and many needs studies still rely exclusively on design standards to define needed levels of investment.

The approach to defining investment needs recommended here recognizes that, from a practical point of view, the appropriate level of investment in any particular facility will depend on many factors in addition to the specific physical conditions of, and quality of service provided by, the facility. The general condition of the rest of the system of which the facility is a part; the role and importance of the facility in the overall system; and the total resources available—all should influence the type of improvements that are appropriate for any particular facility. In fact, given the interdependencies between all the components of an infrastructure system and the relationship between the appropriate level of improvement for a particular facility and the total budget available, it may often be necessary to define several investment levels or scenarios. The effectiveness of each potential investment level, in terms of performance and impact criteria, would have to be evaluated before the

appropriate or "needed" investment level could be defined with any degree of rigor. Except for certain minimum criteria, as discussed in the next section, design standards or policy may have to be determined as part of the investment needs and resource allocations process—not as an input to or a constraint imposed on that process.

While in general we are arguing for a broader definition of needs and a more complex needs assessment process, we do recognize that there may be instances in which decision makers simply want to know what it would take to bring elements of the public infrastructure up to certain standards. It is simply our feeling that when such analyses lead to widely varying ranges of needs or needs estimates far in excess of reasonably available resources, the results are of limited value and a poor guide to where to allocate less than the "needed" amount of investment.

The Role of Standards

While in many needs studies there has been an overreliance on using design standards as a yardstick for measuring needs, there is an important role for standards in defining capital infrastructure needs. Standards can help ensure that consistent approaches are used in improving similar facilities, provide for compatibility of all elements in a system to ensure continuity of service, offer potential cost savings by limiting the scope of potential improvements, and, most important, represent one key mechanism to provide for public safety through good engineering design. Given these important functions, the issue is not whether design standards are required but what level of service (including safety) they should reflect and how much flexibility should be allowed to tailor improvement or maintenance strategies to particular facilities.

There is a critical need to reexamine current standards applicable to each public system. Questions that need to be addressed include:

- Have standards risen too fast to be realistic guides for wholesale rehabilitation of extensive existing infrastructure that has been put into place over many decades?
- Do older facilities really have to meet new facility standards?
- Have the reliability versus risk assumptions embedded in current standards created too great a margin of safety for a given facility in light of systemwide rehabilitation needs?

When standards are being set by different levels of government, an additional question must be asked about different perceptions of needs and good design practice at the federal, state, and local levels. Again, there will be cases in which consistency and uniform standards may be appropriate, but in many others the costs of such uniformity simply does not make sense given a backlog of critical structural or safety needs that can be addressed with "substandard" approaches.

The overriding issue in the debate over the appropriate level of standards is whether it is better to improve a few facilities to stringent standards or many more to lower standards. Obviously the answer depends on what the lower standards are and what they imply for safety, service, and ultimately the cost-effectiveness of the pattern of investments proposed for an entire infrastructure system.

Summary

It is becoming clear that the concept of needs embodied in the traditional infrastructure needs study is inappropriate for dealing with the problem of allocating funds to a range of infrastructure areas or particular facilities within one area. Typically these traditional studies:

- have not reflected any policy choices or alternative service levels;
- have been unrelated to what might actually be accomplished with less than the "needed" level of resources;
- have defined projects that may or may not be cost-effective investments, irrespective of the actual budget available; and
- have been no real guide to tough priority decisions at the facility-by-facility level.

What is necessary to replace this approach is a process that relates the investment level that is thought to be needed to the productivity or effectiveness of those investments compared with different investment levels and ultimately investments in other areas as well. Thus a broader needs approach requires a more refined evaluation process to ensure that scarce funds are employed most productively.

Because traditional needs studies have been divorced from the process of fund allocation to infrastructure areas, geographic regions, or specific projects, the results have tended to be estimates

of dollar needs far in excess of the funds available. Such studies have been of limited usefulness in guiding investment decisions on how to effectively use a much smaller amount of money. If the funds for a major capital investment identified as needed by such a study were simply not available, the study would not be of much use in determining where smaller investments would be most effective. In short, needs cannot be defined in a vacuum. Consideration of realistic budget levels, multiple objectives, and the most efficient way they might be met requires that needs studies evolve as part of a much broader allocation and investment planning process.

THE CONDITION ASSESSMENT PROCESS

Defining Conditions

The previous section pointed out the need for accurate, reliable information on facility conditions as the first step in determining need. This section discusses condition assessment in some detail both to review current practice and to suggest approaches that have been successful.

Condition assessment includes the process of measuring the physical condition of facilities, using specific, clearly defined indicators. It should be based, to the extent possible, on observable and measurable indicators to limit judgment and ensure consistency. Various studies have used readily available fiscal measures like maintenance budget trends as surrogates for condition measures. It should be clear that maintenance investment per year, even if it is dropping over time, does not indicate the existing condition of facilities. Likewise, capital investment trends do not indicate current condition.

Condition Assessment Measures

Condition assessment is a critical element of the overall needs assessment process. It should be reviewed in some detail. Facility condition must be assessed on several dimensions, including safety and structural integrity, adequacy of capacity, quality of service, and system role. The overall condition of a facility is actually a composite of its rating on each dimension. In addition, it is necessary to recognize that these dimensions embody inherent value judgments that affect the evaluation. For example, most would agree that the structural safety of a bridge is more important than its ride quality.

Safety and Structural Integrity Protection of public safety is a primary requirement for public facilities; therefore all facilities must be structurally sound and safe for public use. The potential risk from structural failure varies widely by type of facility, with bridges representing very high risks and water and sewer lines considerably less risk. It is necessary to evaluate the structural condition and its importance to public safety.

Capacity All infrastructure facilities are designed to provide a specific level of service, generally measured in units per time. Examples include highways with capacities in thousands of vehicles per hour and water facilities with capacities of millions of gallons per day. Facilities must be evaluated to determine whether they have adequate capacity to meet demand. It should be recognized that most facilities have a dual capacity, that is, they are rated at so many gallons per day at a given pressure. The rated capacity can be increased by reducing the level of performance. This point is important to remember, because it is possible in many cases to slightly reduce the level of performance, increase the rated capacity, and not significantly affect the public.

Quality of Service Measures of the quality of service vary widely by facility type. Smoothness of ride is used as a major criteria in evaluating street pavement, while measures of reliability of service can be used to measure the quality of water and sewer lines.

Role The relative importance of facilities varies from minor to absolutely essential, depending on how the temporary loss of the facility would affect the overall system, the number of people or households involved, and the extent of inconvenience. As an example, the loss of pumping facilities at a city's water treatment plant would have a much greater impact on the water system than a break in a small main on a local city street. The pump loss could disrupt water service to the entire city, causing widespread disruption, while the main break may only inconvenience a few households.

In evaluating the condition of facilities, it is necessary to consider both the physical condition and the facilities' role so that priorities can be established. The national bridge inventory and inspection program is an excellent example of a systematic, well-designed condition assessment process. The next section discusses it as a good case study of how condition assessment should be conducted. A second case study, on New York City's water distribution system, is presented to show

how agencies can use readily available records to define conditions better and prioritize replacement needs when it is not possible to do more detailed inventories of each facility.

Age In contrast to these case studies, an approach that often has limited value is comparing the annual level of replacement and rehabilitation activity with the system inventory to determine the replacement cycle for the facilities that can be compared to their estimated useful lives. For example, water mains are often reported to have a "useful life" of 100 years. If a city replaces 1 percent of its mains each year, then the replacement cycle would be 100 years, the same as the useful life. If the city replaced 0.5 percent per year, the replacement cycle is 200 years, double the useful life.

This approach has several major flaws that limit its value as an infrastructure needs assessment measure: (1) there are no uniformly acceptable estimates of useful life; (2) facility deterioration depends on many factors, including initial design, quality of construction, use of the facility, quality of maintenance, and the conditions to which the facility has been exposed; and (3) it does not recognize actual facility performance. Useful life estimates for infrastructure are subject to wide variations because of major differences in design practice, the loads and stresses experienced, weather effects, and maintenance practices. Thus average values have limited use because they ignore the substantial differences in the forces that cause deterioration, stresses, wear and tear, and corrosion. Differences in weather, design practices, and maintenance are often more significant in assessing replacement need than the facility's age.

Finally, the replacement cycle approach ignores the actual operating performance of the facility as an indicator of replacement needs. Decisions on replacement should be based on actual conditions, not simply a facility's age. Many facilities need to be replaced or rehabilitated before their theoretical useful life, while others may not need replacement for many years after. The actual operating experience provides the best indication of facility condition.

The National Bridge Inspection Program

In response to the collapse of the Silver Bridge in West Virginia in 1967, the U.S. Congress mandated a national bridge inventory and inspection program for all highway bridges over 20 feet in length. Originally only bridges in the federal aid system, eligible

for federal bridge rehabilitation or replacement funds, were included in the inventory. Now all highway bridges are inspected every 2 years and are eligible for federal bridge funds (though Congress mandates that 65 percent of the funds must be spent on the federal aid system).

State transportation and highway departments are responsible for conducting the inventory and inspection program, which is often done in cooperation with local officials. The Federal Highway Administration mandates that 90 inventory and appraisal items be recorded for every bridge, using a standard rating sheet like that shown in Figure 2-1. Many states use their own rating forms and often collect more information than is needed to meet the federal requirements. The condition and appraisal ratings for items 58-72 on the rating sheet are based on a 9-point scale.

To help guide decisions on individual bridge priorities, the Federal Highway Administration develops a sufficiency rating using the same inventory and appraisal data base used to generate the needs estimate and to allocate funds, but it uses a different analysis procedure. A bridge sufficiency rating is developed to identify the specific bridges that are eligible for funds for replacement (sufficiency rating of 50 or less based on a 100-point scale) or rehabilitation (sufficiency rating of 50-80). While the sufficiency rating combines a variety of structural and service characteristics, it is recognized that any such rating system is somewhat arbitrary. Thus, while the sufficiency rating is used to screen bridges for eligibility for replacement and rehabilitation, states and local communities are not expected to and generally do not set bridge priorities strictly on the basis of the federal sufficiency rating. Furthermore, simply because a bridge has a sufficiency rating of 50 or less does not mean that the appropriate action is replacement. Many factors, including a state's total allocation of bridge funds, ultimately determine what improvement is funded for any particular structure.

The National Bridge Inspection Program represents an important step in assessing the nation's bridge replacement and rehabilitation needs. It created the first real inventory of the nation's bridges and has attempted to develop a consistent data base and rating system for each structure. It has provided a basis for estimating national needs and lobbying for funds, allocating funds, and identifying the specific bridges with the most serious deficiencies. Notwithstanding these positive results, the limitations of the national needs estimate and individual bridge ratings must be recognized if the funds avail-

STRUCTURE INVENTORY & APPRAISAL SHEET

Revised 12-78

IDENTIFICATION

1 State
2 Hwy District
3 County ____ 4 City/Town ____
5 Inventory Route ____ ☐ On ____ ☐ Under ____
6 Features Intersected
7 Facility Carried by Structure
8 Structure No. ____ 1 of ____
9 Location
10 Min. Vertical Clearance, Inv. Rte. ____ ′ ____ ″
11 Milepoint
12 Road Section No
13 Defense Bridge Description
14 Defense Milepoint
15 Defense Section Length
16 Latitude
17 Longitude
18 Physical Vulnerability
19 Bypass, Detour Length
20 Toll
21 Custodian
22 Owner
23 F.A.P. No.

CLASSIFICATION

24 Highway System
25 Administrative
26 Functional

	By	Date
Transfer of Date		
Maintenance Insp.		
Condition Analysis		
Appraisal		
Cost Estimate		
General Review		

STRUCTURE DATA

27 Year Built
28 Lanes on Str. ____ under ____
29 ADT ____ 30 Year ____
31 Design Load
32 Appr. Rdwy. Width and Shield ____
33 Br. Median ☐ None ☐ Open ☐ Closed
34 Skew
35 Structure Flared ____ ☐ Yes ☐ No
36 Traffic Safety Features
37
38 Navigation Control ☐ Yes ☐ No
39 Vertical ____ ft.
40 Horizontal ____ ft.
41 Open, Posted, or Closed
42 Type Service — Code
43 Structure Type-Main
-Approach
45 No. of Spans-Main
-Approach
46 Total Horiz. Clearance ____ ft.
47 Max. Span Length ____ ft.
48 Structure Length ____ ft.
49 Sidewalk ____ Length ____ ft. ____ Width ____ ft.
50 Br. Roadway Width (curb-curb) ____ ft.
51 Deck Width (out-out) ____ ′ ____ ″
52 Vert. Clearance over Deck ____ ′ ____ ″
53 Underclearance-Vertical ____
54 -Lateral-Right ____ ft.
55 -Left ____ ft.
56
57 Wearing Surface

CONDITION

	Material	Condition Analysis	Rating
58 Deck			
59 Superstructure			
60 Substructure			
61 Channel & Channel Protection			
62 Culvert & Retaining Walls			

63 Estimated Remaining Life ____ 65 Approach Roadway Alignment ____
64 Operating Rating ____ 66 Inventory Rating ____

APPRAISAL

	Deficiencies	Rating
67 Structural Condition		
68 Deck Geometry		
69 Underclearance-Vertical (Lateral)		
70 Safe Load Capacity		
71 Waterway Adequacy		
72 Approach Roadway Alignment		

PROPOSED IMPROVEMENTS

73 Year Needed ____ Completed ____ Describe (item 75)
74 Type of Service
75 Type of Work
76 Improvement Length ____ ft.
77 Design Loading
78 Roadway Width ____ ft.
79 Number of Lanes ____ 80 Prop. Rdway Improvement-Year ____
81 ADT ____ 82 Year ____ 83 -Type ____

Remarks:

84 Cost of Improvements ____ $ ____ , ____ , ____ .000
85 Prel. Engrg. ____ $ ____ , ____ , ____ .000
86 Demolition ____ $ ____ , ____ , ____ .000
87 Substructure ____ $ ____ , ____ , ____ .000
88 Superstructure ____ $ ____ , ____ , ____ .000
89 Insp. Date ____

FIGURE 2-1 Bridge inventory and rating sheet.

able for bridge improvements are to be used as effectively as possible.

The General Accounting Office (GAO) reviewed the National Bridge Inspection Program in their August 11, 1981, report to Congress, "Better Targeting of Federal Funds Needed to Eliminate Unsafe Bridges." Among the report's many findings were two of importance to this discussion: incomplete, inaccurate, and unreliable data were detected; and inconsistency in bridge inspection ratings was a major concern.

The GAO found several instances of incomplete, inaccurate, and unreliable data, including a case in which 10 percent of a state's bridges were inadvertently deleted from the inventory. In addition, there were many cases of missing data, such as estimated costs for rehabilitation or replacement and bridge ownership. Finally, the GAO found that bridge inventory data were not being updated in a timely manner. Many of these data problems have been corrected since the issuing of the GAO report, which pointed out that these problems were understandable considering the substantial effort required to develop a national survey in a 3-year period.

The GAO's other major findings of inconsistency in bridge inspection ratings are more disturbing:

- Inspection officials rated bridge components differently because of the amount of judgment involved.
- Some states did not use the Federal Highway Administration's bridge description ratings but had developed their own.
- The number of officials used to inspect and rate about the same number of bridges and the cost of inspections varied considerably by state.
- A wide variance existed in the percentage of deficient bridges between states that appear to have similar conditions.

The GAO's findings point out the difficult problems of trying to determine existing facility conditions. The engineering, procedural, and logistical problems are tremendous. These problems, coupled with short schedules and competition for federal aid, could seriously distort the survey results. It is critical to recognize the major difficulties in assessing the true condition of facilities and develop programs that obtain accurate condition information, because substantial investments are based on these data. The decisions will only be as sound as the condition information. Since the bridge survey is one of the best examples of a comprehensive and tech-

nically sound national condition assessment program, its problems should be carefully studied to ensure that they are avoided in other surveys of infrastructure condition.

The New York City Water Distribution System

The National Bridge Inspection Program is an example of a federally funded, well-designed, comprehensive condition assessment program. There are steps that local public works agencies can take to significantly improve their knowledge of facility conditions. The New York City water distribution system provides a case study of how existing records were used to evaluate the condition of a water distribution system without extensive field surveys. While the results are not as valuable as a complete survey of conditions, it does show how agencies can begin to improve their condition assessment by using available resources.

New York City has one of the largest and oldest water distribution systems in the United States. On May 7, 1979, the Office of the City Comptroller issued a report, "Rebuilding During the 1980's: New York City's Capital Requirements for the Next Decade." As part of this report, the water distribution replacement needs were evaluated to determine their capital costs. The report concluded in part, ". . . approximately $2.45 billion should be spent over the next decade to replace 39 percent of the City's water main (2,404 miles) and 8 percent of the valves that are at least 60 years old and have exceeded their design life." This recommendation was based on a replacement cycle concept that took the useful life of water mains and valves to be 60 years. Digging up 39 percent of the city streets in a 10-year period would create major traffic problems, but would it solve the city's water main problems?

The state of New York, in cooperation with the city, requested the Army Corps of Engineers to investigate the replacement needs for water distribution mains. The Corps, through a consultant, evaluated citywide water main condition trends and conducted a detailed investigation of Manhattan's water mains. Comprehensive investigations of water main conditions should consider structural conditions of the pipes, the hydraulic adequacy of the system, and water quality. A detailed survey of this nature would cost millions of dollars, far beyond the available funds. Since structural deterioration of mains was a major area of concern, the study focused on this facet. Water main breaks were used as an indicator of structural

TABLE 2-2 Trends in New York City's Water Main Breaks, 1940-1978

Borough	Percentage Increase
Manhattan	0.6
Bronx	2.2
Brooklyn	2.5
Queens	2.9
Staten Island	3.8
New York City	1.7

deterioration, not necessarily because it is the only or best measure, but because it was an acceptable indicator of structural failure that was readily available.

Citywide analysis indicated that the rate of breaks was increasing 1.7 percent per year in the 1940-1978 period. The break rate trends, however, varied markedly by borough, as shown in Table 2-2. Comparison of break rates among boroughs provided additional information about the variation in water main breaks across the city. Review of the trends indicated that Manhattan had a relatively slight rate of increase in break rates, but it had a much greater rate of failure. Table 2-3 presents a comparison of break rates by borough for all mains, and 6-inch- and 12-inch-diameter mains.

This relatively simple analysis indicated that Manhattan was experiencing a break rate 3 to 7 times greater than the other four boroughs. Thus, while Manhattan's rate of breaks was not increasing as rapidly as the other four boroughs, its failure rate was much worse. In fact, there were 12 tracts in Manhattan experiencing 14 times the four-borough break rate for 6-inch mains.

In order to investigate water main break problems in more detail, a computerized inventory of Manhattan water mains was developed, and break histories for each main were developed. An extensive set of analyses were conducted to define break patterns and to see if a predictive model of main failure could be developed. The results indicated several important findings:

- The water distribution system mains were not in danger of imminent collapse.
- Main break rates were not related to age.
- Location may be the single most important factor in predicting main breaks.

TABLE 2-3 New York City Annual Breaks—1,000 Miles (1975)

Area	All Mains	Twelve-Inch Mains	Six-Inch Mains
Citywide	68	56	158
Manhattan	167	116	610
Four boroughs	55	35	87
Ratio: Manhattan/four boroughs	3.0	3.3	7.0

• Replacement should be targeted to those mains with the worst break records, regardless of age.

This study demonstrated that careful analysis and effective use of existing records could significantly improve both (1) the understanding of facility conditions and (2) the development of capital replacement programs. Targeted replacement based on demonstrated need could reduce costs dramatically when compared with estimates based on useful life and replacement cycle planning.

THE INVESTMENT DECISION-MAKING PROCESS

Estimating Investment Requirements

A number of different approaches have been used to estimate the level of investment required for various public facility systems. Some of these approaches have been very simplistic, reflecting the absence of sound inventory and conditions data. For example, extrapolating past trends of investment levels in a particular sector and using a replacement cycle rule of thumb have both been used to forecast future needs. Although such approaches may be necessary in the absence of good information on conditions, they are likely to produce only a very crude estimate of real investment needs.

When facility conditions data have been available (on the basis of either a comprehensive inventory and inspection or surveys and other indicators), most needs studies have compared observed conditions with a set of accepted design standards to define and estimate the cost of "needed" improvements. Even when such an approach is applied to the results of a rigorous and comprehensive conditions assessment (as recommended above), the estimates of need may be of limited use. As discussed earlier, uniform design

standards are often not a good guide to the appropriate level of investment for a specific facility when budgets are tight and there are many systemwide needs.

There simply may be no easy shortcut from a comprehensive facility conditions assessment to recommendations about the appropriate level of investment. Such recommendations would depend on the specific pattern of facility improvements that can be obtained for any given level of resources. Recommendations on needed levels of investment should therefore be a product of a much broader decision-making process about investments rather than a basis for it. In many cases, it will be more productive to improve the decision-making process at different levels of government than attempt, in the absence of changes to the investment planning process, to develop more sophisticated improvement standards or definitions of need.

A Framework for Investment Decisions

In maintaining existing infrastructure, public works officials face two interrelated questions:

- What level of investment is required?
- What specific projects should be selected?

Officials reach these decisions each year either systematically or in an ad hoc manner. Of course, in many cases the answer to the first question is highly constrained, and sometimes the question is not explicitly addressed. Increasingly, local officials will turn to the staff of the public works agency for guidance. Most agencies make these decisions in a loosely structured fashion. Lists of "necessary" projects are reviewed and those within the available budget resources are selected. Decisions are often based on the strength of individual arguments and whether projects are ready for implementation, rather than on a step-by-step review of project needs and the assignment of priorities.

This approach, proven and workable, rests on the premise that the important projects will climb to the top of the list. Experience shows that this does happen in most cases. There is no assurance, however, that the most effective mix of projects is selected. In situations in which projected need exceeds available funding, there remains a question of whether the agency is getting the most from its investment.

To provide a better approach to both estimating the level of investment required and selecting the appropriate mix of specific facility improvements, we suggest a broader investment planning framework. The major purpose of such a framework is to emphasize that decisions about the appropriate level of investment and the specific pattern of facility improvements to fund cannot be treated separately. The major activities in the proposed needs assessment framework are shown in Figure 2-2. While there is a danger in oversimplifying any decision-making process, several critical steps must be taken to develop investment needs estimates:

1. develop a facility inventory;
2. establish performance criteria and conduct a conditions assessment;
3. identify deficiencies;
4. develop funding scenarios and program priorities;
5. develop and evaluate alternative projects;
6. evaluate program/project alternatives; and
7. select a program option.

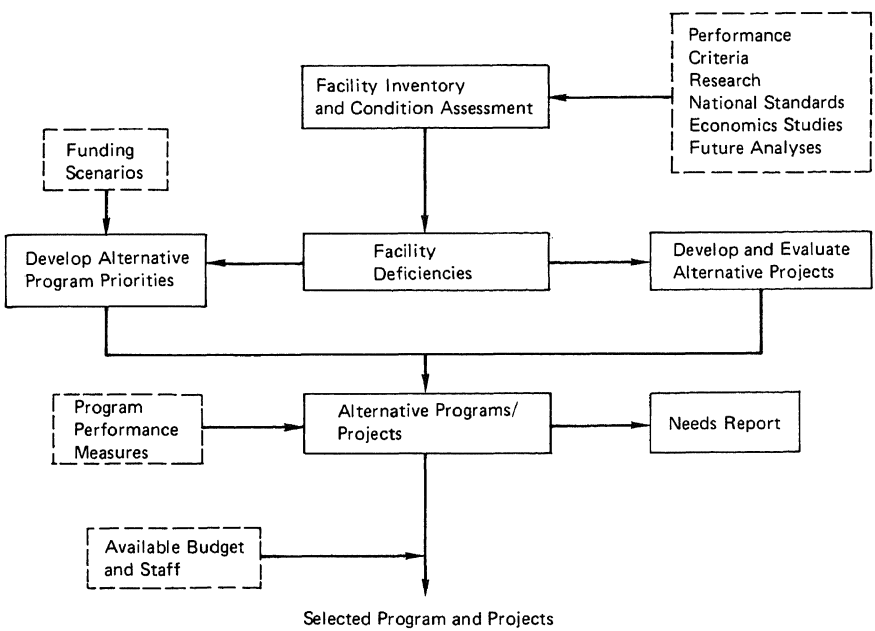

FIGURE 2-2 A framework for infrastructure needs assessment.

As described in the previous section, the first three steps are needed to provide the type of facility-specific information on which to base systemwide investment decisions. These steps are described in more detail below.

1. *Develop a facility inventory*—An accurate inventory of all infrastructure facilities with sufficient technical and maintenance information should be established and updated on a regular basis. This inventory should be permanent and should be updated with information on all changes, such as the building of new facilities and major changes to existing facilities.
2. *Establish performance criteria and conduct a conditions assessment*—A set of facility performance criteria should be established to evaluate the condition of facilities. These criteria should be reviewed periodically and should not be overly restrictive. Current national standards may not be appropriate in many cases because they may not reflect local conditions and problems. Systematic surveys of all facilities should be conducted on a routine basis, e.g., annually or biennially. The nature and extent of the surveys will vary by infrastructure type; however, the idea in each case is to assemble consistent information on all facilities so that the current and likely future condition of these facilities can be determined.
3. *Identify deficiencies*—The facility condition survey results should be compared with the facility performance criteria to identify those elements of the system that do not meet the criteria. It is important that the survey data provide sufficient information to allow comparisons of conditions with performance data. Those facilities identified as deficient are candidates for follow-up analysis to define alternative projects to correct the deficiencies.

The next four steps in the proposed investment planning framework focus on how to proceed from a sound conditions assessment to judgments about needed levels of investment and particular project priorities. They reflect a strong belief that needs estimates developed independent of any sense of overall fiscal constraints and explicit priority setting are simply not likely to be very meaningful for setting overall budget levels and will be irrelevant in making facility-level resource allocation decisions:

4. *Develop funding scenarios and program priorities*—While th

ultimate purpose of needs studies is to provide insight into the investment requirements for a particular facility system, it will generally not be useful to develop facility needs lists in the abstract with no reference to potential overall budget levels. Definitions of needs and priorities can change dramatically in the face of specific resource constraints. The most practical way to get some measure of the needs being addressed and the urgency of different needs is to apply the discipline imposed by specific funding constraints. These constraints, or funding scenarios, should be used to show what can be done for various levels of budget above existing levels. In addition to a level of funding being used to define each scenario, some guidelines on the priorities that should be addressed at any level should also be established. These guidelines will necessarily represent explicit value judgments about the most critical deficiencies uncovered in Step 3.

5. *Develop and evaluate alternative projects*—For each of the facilities identified as deficient (or possibly only for facilities with severe deficiencies), alternative improvement levels or projects should be developed. The specific level of improvement appropriate for any facility will depend on the nature and severity of the deficiencies identified, the priority established for addressing specific deficiencies, the relative condition of other facilities in the system, and the overall resources available.
6. *Evaluate program/project alternatives*—For each funding scenario established in Step 4, a program option (consisting of specific facility-level improvement) can be developed to reflect the priority established for different types of deficiencies (e.g., safety versus capacity) and facilities (e.g., water mains versus distribution systems). By evaluating various program options defined both in terms of a resource level and the deficiencies to be addressed, a much more realistic estimate of investment requirements can be made. While such an approach implies a level of effort and detail generally not a part of the traditional needs study, ultimately such a process is necessary to allocate available resources; it should simply be extended to generate needs reports as well as a specific program recommendation.
7. *Select a program option*—While selection of an actual investment program is generally beyond the scope of most needs studies, it is included here simply to suggest the logical conclusion to the steps outlined above. The selection of a final

program reflects many factors, including the resources actually made available.

The steps in this framework for investment decisions describe an approach to investment decision making that integrates the typical needs study in a much broader planning process. The two case studies that follow provide a comparison of two approaches to estimating investment needs. The Environmental Protection Agency (EPA) survey adopted the traditional ad hoc approach to estimating needs, yet it clearly demonstrates how definitions of need and resource allocation decisions are dependent on the standards or criteria selected and the total resources realistically available. The Wisconsin Department of Transportation, in attempting to convince the state legislature that more resources were required for its highway program, adopted an approach more like that outlined above.

The EPA Needs Survey

The Environmental Protection Agency has conducted needs assessments since 1973 to obtain information about investment requirements for publicly owned sewerage facilities. These estimates primarily reflect needs related to national goals for pollution abatement and do not provide a complete definition of sewerage needs. Since these estimates are primarily used to allocate federal grant funds, they may seriously understate or overstate needs.

The enactment of the Federal Clean Water Act of 1972 caused dramatic change in water pollution control, including substantial increases in investments in treatment facilities. The law specified minimum treatment levels for municipal and industrial wastes, established specific time schedules for compliance, and enlarged the federal role in funding pollution abatement efforts by local governments. The goals of the act included secondary treatment of all municipal wastewater by 1977, fishable and swimmable streams by 1983, and the elimination of all pollution discharge by 1985.

In the subsequent 11 years, there have been many changes to the 1972 act, resulting from experience with this overly ambitious program and the realization that the costs of such an effort were much greater than originally anticipated. In this sense, the biannual needs surveys have provided useful information to help redirect the program.

Table 2-4 presents the results of the EPA needs survey, which

TABLE 2-4 Environmental Protection Agency Survey of Needs for Water Pollution Control ($ Billions—Current Dollars)

Needs Category		1973	1974	1976	1978	1980	1982
I	Secondary treatment	17	13	13	15	29	31
IIa	Advanced secondary	6	16	21	21	4	5
IIb	Advanced treatment					1	1
IIIa	Infiltration/inflow	1	5	3	2	3	3
IIIb	Sewer infiltration		7	6	5	6	5
IVa	New collectors	14	18	17	19	18	21
IVb	New interceptors	11	18	18	18	21	18
V	Combined sewer overflows	13	31	18	26	37	36
(SUBTOTAL)		(60)	(108)	(96)	(106)	(120)	(118)
VI	Stormwater needs		235	54	62	114	93
TOTAL		60	343	150	168	234	212

NOTE: Survey results are not comparable due to changes in procedures, definition of allowable projects, and cost estimating procedures.

has been carried out every other year from 1974 to 1982. In reviewing these estimates, it is interesting to note the fluctuations in needs, from a low of $60 billion in 1973 to a high of $343 billion in 1974. These variations are due to the different methods used to compute needs and changing criteria for projects considered eligible for construction grant aid. The EPA conducted the first survey in 1973, using existing project descriptions and leaving gaps where cost estimates were unavailable. In 1974, EPA requested the states to prepare needs estimates that were submitted to EPA for compilation. This approach resulted in a fivefold increase in needs over the 1973 survey. The 1976 survey was conducted by an outside consultant with assistance from EPA's regional offices. Certain stormwater control projects were not allowed, resulting in a significant reduction in needs, compared with the 1974 survey.

The 1977 amendments to the Clean Water Act eliminated storm sewer projects as grant eligible, significantly reducing federal obligations for pollution control costs. The 1978 needs survey showed a 30 percent reduction in eligible needs compared with the 1976 survey because of this change in grant eligibility. Other changes include modifications in minimum treatment requirements for coastal communities, again reducing the needs estimates.

In the 1972-1981 period, EPA obligated $32.2 billion to 22,000

projects for planning, design, and construction. By 1981, however only 4,000 had been completed. Even with this large investment i federal grants, the needs estimates have increased from $60 billio in the 1973 survey to $118 billion in the 1982 survey, if only grant eligible projects are included, or $212 billion, if stormwater need are included. These increases cannot be explained by increasin pollution or inflation alone. Rather, they reflect those factors a well as increased information about the costs of implementing th Clean Water Act. Since the early needs surveys included only avail able estimates of project costs, they did not reflect projects that wer later added to the survey as more data became available.

In 1981 Congress reviewed the nearly 10 years of progress i pollution control under the Clean Water Act and rewrote the ac to reduce the federal responsibility for constructing sewerage fa cilities. The 1981 amendments cut federal spending from $3.9 bil lion in fiscal 1981 to $2.4 billion in fiscal 1982. It also reduced th federal share of costs from 75 percent of costs prior to October 1 1984, to 55 percent thereafter.

The needs surveys, with cost estimates that fluctuate because c changing methods and policies, provided EPA and Congress wit valuable information on the costs resulting from legislation an regulatory procedures. Partly because of the continually rising cost that far exceeded available funding, grant eligibility and pollutio abatement requirements were modified to bring needs more closel in balance with fiscal resources. The needs surveys, while usefu in defining overall fiscal implications of the Clean Water Act, wer of limited value in setting priorities for specific projects. The need surveys focused on the treatment facilities required to meet th act's requirements rather than facilities needed to meet water qual ity goals. As costs have increased and progress has been slow, Con gress has shifted the overall program toward specific water qualit goals, focusing needs more narrowly.

The Wisconsin Department of Transportation's Approach to Investment Programming

Traditional highway programming efforts in many states hav suffered from a variety of problems, including the use of need studies or system plans that reflect unrealistic revenue assump tions, the inability to weight factors to allow trade-offs within an between program areas (e.g., bridge replacement versus highwa

rehabilitation or improvement), the lack of a systematic method for maximizing statewide versus local or project benefits, and a failure to explicitly consider the relationship between maintenance and improvement programs. Generally only one design alternative or potential investment level is considered for each project in developing a program, and projects are ranked either subjectively or by using a more technical method such as a sufficiency rating, a priority index, or benefit-cost analysis. For the most part, little formal program evaluation occurs. In short, the process of program development has been viewed as a somewhat mechanical one of checking off projects on a priority list until available funds are exhausted.

To address these shortcomings, the Wisconsin Department of Transportation developed a new approach to highway investment analysis and programming that was designed to:

- provide a range of policy choices to top management, not simply a single recommended program alternative;
- maximize system benefits over individual project benefits;
- consider alternative design concepts (i.e., investment levels) for each project;
- explicitly develop alternative programs for evaluation; and
- make use of a range of consistent evaluation procedures to evaluate project and program options.

Since the most important objective of the process was to improve the department's investment decision-making capability by providing management with fully evaluated policy choices, it was necessary to develop explicit alternative improvement programs. Developing meaningful alternative programs required, in turn, project alternatives—that is, alternative levels of improvement for a given highway segment. Under certain program assumptions (e.g., constrained revenue), the appropriate level of improvement for a given segment might be a resurfacing or minor reconditioning; under other assumptions (e.g., a revenue increase), a more substantial improvement might be warranted. Unless this dynamic relationship between the scale of projects and program alternatives is explicitly recognized, a key element of program choice is ignored and program alternatives are simply different combinations of projects, each having only one proposed design.

The first step in developing a multiyear program was to thoroughly assess the highway system's physical and service conditions. The assessment of deficiencies for purposes of the 6-year program

specifically avoided a needs study approach and the reliance on traditional highway standards. It instead recognized that, as a practical matter, definitions of need and deficiency vary from time to time on the basis of factors including the public acceptability of existing conditions, the cost of improvements, and revenue availability, among others.

To provide some objective measures of roadway condition, a set of data was collected for the 12,000 miles of roadway in the state system. These data included surface age and pavement condition, accident rates and occurrences, volume-to-capacity ratios, percent no-passing zones, and other geometric and structural criteria. The data for each segment were placed in a computer file for efficient editing, sorting, analysis, and display.

Using the computer information system, a series of reports was produced summarizing the extent and severity of various deficiencies statewide and by district, functional class, etc. These reports were used to help guide the development of specific program alternatives, to evaluate them, and to summarize program performance.

In parallel with the analysis of deficiencies in the state highway system, conditions and deficiencies in the other program areas were identified as well. For bridges, the results of the Federal Highway Administration's Sufficiency Rating Formula and the state transportation department's own priority listing based on load-carrying capacity, overall structural condition, and geometrics were used to assess replacement needs. The cost estimate prepared for the Federal Highway Administration served as a basis for assessing potential improvements on Wisconsin's portion of the interstate system.

Once the screening of deficiencies in the state trunk highway system was completed, alternative improvement plans were developed for those segments judged most deficient. In identifying potential improvement projects, emphasis was placed on segments requiring surface renewal within the 6-year program period and on safety, geometric, and capacity deficiencies. The minimum improvement alternative proposed for each segment was a resurfacing project or a resurfacing project plus the minimum structural renewal necessary to support the new surface. Depending on the severity of the deficiencies present, higher levels of improvement proposed for a given segment varied from minor reconditioning projects to major reconditioning, reconstruction, and major new alignments.

For each alternative improvement proposed for each segment,

data on the key design elements, potential impacts, cost estimates, and schedule were collected and placed in a computer file that could be cross-referenced with the deficiency data file to produce summaries of the deficiencies addressed by different sets of projects and programs.

From the analysis of deficiencies it was clear that a range of key policy issues had to be explored in developing alterative programs, including:

- the benefits available from a revenue increase under varying assumptions about how additional revenues might be spent;
- the benefits of greater emphasis on safety or capacity improvements versus pavement preservation;
- the most cost-effective mix of resurfacing and reconditioning work for maintaining some minimum pavement quality; and
- the trade-off of funding a relatively few major improvements versus many more small improvements.

Given the expected trend in gas tax revenues, the need to explore the potential for a revenue increase and to demonstrate how additional revenues could be used was identified as the most critical issue facing the Department of Transportation.

While the number of alternative programs that could be developed and evaluated was limited, a range of reasonable funding levels was defined for each of four program areas: resurface, reconstruction, and recondition (RRR); bridge replacement; interstate improvement; and major projects.

Table 2-5 shows the funding levels selected for each area. They were based on the results of deficiency analyses described earlier, expected federal funding availability, previous program commit-

TABLE 2-5 Structure of Program Alternatives: Wisconsin Department of Transportation

	Alternative Program Levels (Millions of 1978 Dollars)		
Program Area	Low	Mid	High
Resurface, recondition, reconstruction	200	300	400
Interstate improvements	90	135-195	245
Bridge replacement	70	100	140
Major projects	120	listing of additional projects	

ments, and the policy preferences of top management. The objective was to identify the likely range of expenditures by program area, assuming different total revenue levels and policy directions. Thus, for the general RRR program area, expenditures of at least $200 million (1978 dollars) were estimated to be necessary during the period 1980-1985 simply to meet objectives for surface renewal. Even under the most optimistic scenario (i.e., assuming a major revenue increase), combined with minimum expenditure levels in the other program areas, it was unlikely that RRR program area expenditures would exceed $400 million.

Alternative programs for the RRR area were developed using guidelines that identified targets for miles of surface renewal and other criteria as well as overall funding levels. While district offices were given initial funding targets, it was made clear that their final funding levels would depend on a statewide evaluation of initial district submittals and the desire to develop a consistent program from district to district. Figure 2-3 illustrates the criteria that were expected to be used in determining the appropriate level of improvement; however, overall funding levels and deficiency criteria had to be combined in making project selections. At the lowest funding level for the RRR program area ($200 million), district choices were very constrained by the goal for miles of surface renewal, and the majority of projects were resurfacing and minor conditioning. At higher funding levels there was increasing flexi-

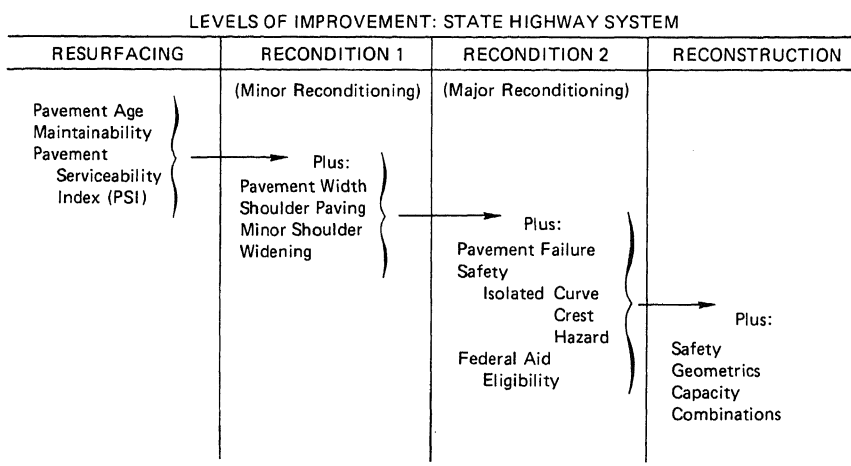

FIGURE 2-3 Criteria used to determine the appropriate level of improvement.

bility to fund major reconditioning projects while still meeting surface renewal goals.

Some consideration was given to specifying relatively rigid rules or priority thresholds (e.g., accident rate above a specified level, etc.) for projects proposed for higher-level improvements. However, subject to meeting goals for surface renewal, districts were given wide latitude to set priorities. Initially this was a more prudent approach, given variations in conditions from district to district and a lack of agreement on the acceptable range for any threshold criterion. More defensible threshold criteria could be set in future cycles, depending on the degree of variation occurring in initial district submittals.

The development of alternative bridge, interstate, and major highway programs was also guided by an explicit set of priority and policy guidelines, yet the use of a strict formula was also avoided. For bridges, primary consideration was given to load-carrying capacity and posted limits, overall structural conditions, geometrics, age, and traffic levels. For interstate improvements, priority was given to completion of the system and selected operational and safety improvements on existing facilities.

Unlike the National Bridge Inspection Program and the EPA survey, the Wisconsin Department of Transportation's approach to capital investment programming was not designed to produce an overall needs estimate for highways based on a set of physical and service standards. Rather, it was developed to provide a realistic appraisal of what could and could not be accomplished with a number of different revenue levels to guide individual project selection. It did serve the purpose of many needs studies by providing the basis for state legislation to increase highway revenues twice since 1980.

SUMMARY AND CONCLUSIONS

Needs Assessment Issues

In evaluating the state of the art in needs assessment, we have identified several issues that should be considered in discussing infrastructure needs. While there are many technical, financial, managerial, and administrative issues, we feel these three deserve particular attention.

The Limited Use of Traditional Needs Surveys

Traditional needs surveys can be classified as studies that d
termine projected needs based on whether facilities satisfy a giv
set of standards. These surveys are necessarily general, based
assumptions that, while reasonable at the abstract level, are
limited use at the specific facility level. The broader the survey
scope, the greater the potential of overgeneralizing the situatio
because of the use of broad assumptions and the failure to elimina
marginal projects, which, while desirable, could be eliminated wit
out undue burden on the public.

There are two possibly conflicting desires in defining needs, e
pecially at the national level. The first is to develop total costs
that the magnitude of the problem can be determined. The oth
is to develop detailed, useful information at the local level whe
trade-offs and project selections can be made. The National Brid
Inspection Program satisfied both desires well because it was bas
on sound, technically reliable data that could be used at the federa
state, and local levels.

Surveys in other areas should follow the bridge prototype
building an information base that is both technically realistic a
can be updated. For some infrastructure systems and at some leve
of government, surveys of all facilities will not be possible. Mor
over, caution must be exercised at the local level in interpreti
and using the results of such studies for estimating needs and s
lecting projects. Single-purpose surveys to develop theoretical nee
should be avoided, because they will not reflect real needs and th
do not further state and local information and decision-maki
requirements.

The Importance of Technically Sound Condition Information t Effective Infrastructure Management

No one knows the true condition of the nation's infrastructu
because assessment data are highly fragmented and there are maj
gaps in information. There is a serious need for technically sou
and accurate information to avoid unwise investments based
questionable criteria.

Public works agencies should place high priority on the tasks
determining and continually updating information about the co
dition of public facilities. This information is necessary to provi

a base for all investments in maintenance. Without reliable information, there are no assurances that facility conditions will be affected by investments. Replacement needs can be more precisely determined if sound conditions data are available.

Agencies should adopt a three-phase approach to developing reliable condition data:

- develop a facility inventory with a performance monitoring records system;
- conduct routine condition surveys; and
- conduct research on facility failures, trends, and alternative solutions.

Conditions vary widely from agency to agency and within agency systems. Pragmatic applied research into agency patterns, coupled with sound information in a usable information management system, will benefit the agency substantially.

The Importance of the Investment Decision-Making Process

Public works agencies must reevaluate their decision-making process for capital and maintenance investments to ensure that the best allocation of resources is made to programs and to projects within programs. With substantial needs and limited resources, it is critical to get maximum value from available funds. In many cases, this may require significant changes in program management and maintenance practices. Careful systematic analysis, like that suggested above, cannot increase funding; it can, however, ensure that the available funds are spent more effectively. This will require reassessing both capital and operating budgets in setting priorities to ensure that the most critical projects are selected.

Research Agenda

There are many potential areas of research on the management of infrastructure maintenance. We believe that research on the technical aspects of condition assessment, the role of standards on investment, and the investment decision-making process are fruitful areas for study.

Particular areas of research include:

- *Conditions Assessment*—Research on existing methods of assessing infrastructure for each type of facility should be conducted

with the objective of recommending measures for assessing structural integrity, adequacy of capacity, quality of service, and facility role. Additional research should also be done to determine facility deterioration rates under varying conditions and the appropriate criteria for measuring and monitoring facility conditions over time.

- *The Value of Information Systems in Condition Assessment*—It would be useful to analyze the experiences of federal, state, and local agencies in the use of information systems in infrastructure management. Are the full potentials of these technologies being realized?
- *The Role of Standards*—Research is needed on the technical, economic, and legal implications of the standards promulgated by professional associations, trade groups, and the federal government. Are standards continually rising, and, if so, what are the implications of "standards creep" on infrastructure decisions? More analysis of the cost of additional standards or regulations should be performed.
- *The Role of Risk Analysis in Infrastructure Decision Making*—Are risk analysis methodologies being used in decision making and, if not, what are their potential benefits in determining conditions and evaluating options?
- *Life-Cycle Cost Analysis*—Research is needed to determine the most appropriate repair, rehabilitation, and maintenance strategies for different facility systems, including a further exploration of the different maintenance options available for each facility system.
- *Methods for Evaluating Benefits and Costs*—Knowledge is very limited about the benefits and costs of various levels of system conditions and performance and the trade-offs involved in maintaining different levels of service. Improved approaches for this type of analysis are needed within each infrastructure area and to compare the effects of improving one infrastructure system (e.g., highways) with another (e.g., water distribution).

BIBLIOGRAPHY

American Public Works Association
1981 *Public Works Management Trends and Development.* Special Report 47. Chicago: American Public Works Association.
1981 *Revenue Shortfall.* Chicago: American Public Works Association.
Choate, Pat, and Walter, Susan
1981 *America in Ruins: Beyond the Public Works Pork Barrel.* Washington, D.C. Council of State Planning Agencies.

Comptroller General of the United States
1981 Deteriorating Highways and Lagging Revenues: A Need to Reassess the Federal Highway Program. Report prepared for U.S. Congress, March 5.

CONSAD
1980 *A Study of Public Works Investment in United States.* Washington, D.C.: U.S. Department of Commerce. Available from the National Technical Information Service, Springfield, Va.

Cooper, Thomas W.
1981 State Highway Finance Trends. Report prepared for the Federal Highway Administration, Washington, D.C.

Federal Highway Administration
1981 Highway Investment Practices and Trends. Federal Highway Administration, Washington, D.C.

National Chamber Foundation
1981 Transport Tomorrow: A National Priority. Report prepared by Paul O. Roberts and The Center for Transportation Policy Research at the University of California, Berkeley.

National Cooperative Highway Research Program
1980 Synthesis 72: Transportation Needs Studies and Financial Constraints. Report prepared by Thomas F. Humphrey. Washington, D.C.: Transportation Research Board.

National Transportation Policy Study Commission
1979 *Final Report.* Washington, D.C.: U.S. Government Printing Office.

Neumann, Lance A., and Dresser, Joseph
1980 *A New Approach for Analyzing Highway Program Choices and Tradeoffs.* Washington, D.C.: Transportation Research Board.

O'Day, D. Kelly
1981 Philadelphia Infrastructure Survey. Center for Philadelphia Studies, School of Public and Urban Policy, 4025 Chestnut St., Suite 600-T7, University of Pennsylvania, Philadelphia, Pa. 19104.

Peterson, George E., ed.
1981 *America's Urban Capital Stock.* Six vols. Washington, D.C.: Urban Institute.

Phillips, Bruce A.
1980 The Deterioration of U.S. Roads: Estimates of Dollar Needs. General Motors Research Pub. GMR:3515.

Reed, Marshal
1981 Principles of Highway Finance. Highway Users' Federation, Washington, D.C.

U.S. Army Corps of Engineers
1980 New York City Water Supply Infrastructure Study. Vol. 1: Manhattan. N.Y. District, U.S. Army Corps of Engineers.

U.S. Secretary of Transportation
1981 A Revised Estimate of the Cost of Completing the National System of Interstate and Defense Highways. Report to the U.S. Congress.
1981 The Status of the Nation's Highways: Conditions and Performance. Report to the U.S. Congress.

Wisconsin Department of Transportation
1980 Six Year Highway Improvement Program 1980-85. Unpublished report.

he example of the bridge survey, the question is whether lifferent raters will come to the same determination with re- gard to the condition of a facility. We can improve both the echniques and the training involved so that more reliable esults can be obtained and they can be used by decision mak- rs with greater confidence. We must also be concerned with he cost of those procedures. For local and state government o regularly monitor the condition of their facilities, they must ave methods that are relatively practical and inexpensive. Therefore, we should look particularly for low-cost approaches.

mproved information on the rates of deterioration of different ypes of infrastructure. Some work has been done on this topic, ut it is just a beginning. There is a need to develop data on leterioration rates that take into consideration such condi- ions as soils, weather, loading factors, materials used, and onstruction methods rather than merely to provide averages or particular facilities at national or even citywide levels.

Better analytical tools for making trade-off analyses. There is need to use risk, cost-effectiveness, and cost-benefit analyses nd other tools to deal with multiple criteria, nonlinearities, nd uncertainties. Local governments need to know which echnique should be used and to what extent for specific sit- uations. Too many governments use a simple "worst first" pproach to determining how to set their priorities. That a acility is near collapse does not necessarily mean that its epair or replacement should be given top priority. It may, for nstance, be far more cost-effective to devote resources to pre- ventive maintenance of facilities that are heavily used than o repair a facility that is less important in the functioning of he system. In other cases, such as water mains, a low rate of ailure may offer a policy choice of accepting the temporary disruption caused by such failures and to undertake a program f emergency repairs rather than a far more costly systematic eplacement program.

More comprehensive information on individual maintenance lternatives. This includes information on the service quality, ife effects, and durability of a facility. It would be desirable o develop a cost and durability handbook providing ranges of osts, under different conditions, for different types of main- enance options.

asically agree with the major points made by O'Day and Neu-
n, and I will expand on their material to suggest a research
da. I particularly like the way they have defined needs as-
ment in a broad way, not only looking at condition assessments,
lso looking at specific facilities, the alternatives available, and
evels of available funding.

t me address briefly the problem of choice, drawing on work
ave been conducting at the Urban Institute. It is a classic
ms problem. First, there is a vital need for inventories and
ition assessments at the local level; unfortunately, there are a
ber of dependent variables that need to be identified. In each
fic case a number of objective criteria must be examined, such
e number of water main breaks, the number of people served,
Second, there are independent, exogenous variables that over-
ach system. For example, soil conditions, weather, traffic loads,
other demand conditions must be considered. They will vary
ng local areas and, in many cases, within different parts of local
s.

r each situation there will be alternative actions that can be
n. These may range from replacement of a facility to emergency
irs and variations of preventive maintenance. For each possible
n there are effects on service quality and costs for the long and
short term. Another important factor is citizen expectation for
level of service a facility provides. There is also, of course,
rtainty about the future and funding constraints.

onlinearities are common in these problems, including inter-
tedness. Scheduling situations arise, for example, when it is
ible to deal with more than one problem at a time due to an
rgency response to a single problem, such as major road repair.
ay be possible and more efficient to repair the sewers and water
ns at the same time.)

hile local governments must make the ultimate choices about
t to do, our focus should be on a national research agenda, which
ultimately help local and state governments help themselves.
major topics should be included in the agenda.

Improved condition assessment tools. While methods have im-
proved in recent years, there is room for still more improve-

5. *Better information on new technologies.* There are a number of new technologies that are available but have not gotten to the public works departments. Information on new technologies is fragmentary and incomplete. Information is especially needed on the conditions under which these technologies are applicable.
6. *The issue of regulations and standards, particularly those that are generated nationally.* Standards can cause many problems. What is needed is an independent and professional check of standards and analysis of their implications and effects on immediate costs and on operating costs over the long run.

These are difficult research issues, but action on them could make the process of choice substantially easier for local governments.

Kurt W. Bauer

O'Day and Neumann have provided us with a valid critique of the shortcomings of infrastructure needs studies conducted to date. Such studies have tended to produce needs assessments, which, because of the sheer magnitude of the estimated need, have low credibility with elected officials and the public. The chapter clearly identifies the need to improve these studies if they are to be used to guide decisions about the level of investment appropriate and the allocation of available resources to specific improvements within a system. It also identifies the questions that should be addressed to improve needs assessments. In particular, needs studies should address issues of priorities between sectors or within sectors so that available resources can be used in the most cost-effective manner. The key problem is to provide a continuing and accurate inventory of the capacity of facilities to meet both current and future requirements for use.

My principal criticism of the chapter is in what it does not say. It does not deal explicitly with one of the most important issues concerning infrastructure: how needs assessment relates to comprehensive planning efforts, including the comprehensive land use plan. This issue is raised but not addressed. For instance, they discuss how needs assessments should be related to the broader investment planning process so as to more rationally allocate resources between and within sectors. These priorities and allocations should be based on a variety of broader social and economic objec-

tives. This is a task that can be accomplished properly only in the context of a comprehensive plan. Indeed, the description of the improved needs assessment process set forth in the paper is a description of the classic comprehensive planning process.

The case studies too are inadequate in their relevance to a comprehensive planning process. The Wisconsin transportation needs study, for example, is clearly an improvement over earlier studies of a similar type, yet it does not relate alternative improvement and maintenance strategies to the highway system as a whole. It did not consider how the development of the highway system would relate to other model systems. These are serious shortcomings impeding the development of the whole system. They are now being corrected by the state transportation department as it integrates its highway plans into the broader state transportation plan.

A similar observation can be made with respect to the EPA survey of wastewater treatment systems. It failed to relate needs for water pollution abatement to detailed areawide plans for water quality management, even though the requirement for such plans was federally mandated.

The serious shortcomings of any needs assessment process, however technically sophisticated, outside the context of the comprehensive planning process are illustrated by a few examples. If, for instance, a needs assessment indicates that a section of a combined sanitary and storm sewer system should be reconstructed, how, in the absence of a comprehensive plan, does one determine whether to reconstruct it as a combined or separated facility? The far-reaching implications of that question deserve some contemplation in the design of needs assessment systems. Such questions extend to other kinds of facilities and systems, such as wastewater treatment, surface and groundwater quality management, and street improvement and maintenance issues. Moreover, such questions extend to issues of land use, development, and redevelopment. The choices made can have important implications for the economic development of an area as well as for issues of social equity in a community. Similarly, if there is a need for a waste treatment plant, how does one decide, in the absence of a comprehensive plan, the size of the plant, the level of treatment to be provided, and the service area to be used? If a bridge must be reconstructed, how can a decision be made on the design capacity and the level of service to be provided without reference to some broader system plan for transportation and land use? These few examples suggest the need to relate in-

frastructure needs assessments and the maintenance and improve ment process to a comprehensive plan.

In summary, the chapter provides a useful critique of the stat of the art of needs assessment. It offers some sound suggestions fo incremental improvement of these processes. But it stops short o addressing one of the key policy issues in infrastructure needs as sessment—the relationship to the comprehensive planning proces Without this relationship such assessments cannot be used as soun guides for determining the appropriate levels of investment in given infrastructure system or the allocation of resources to specif facilities. Only within the context of the comprehensive plannin process can these two important functions be adequately addresse More important, only in that context can one determine the exte to which investment decisions meet broader social and econom objectives. Thus, one of the key policy issues is the relationship infrastructure programs to comprehensive planning objectives.

SUMMARY

Preparation of Inventories and Needs Analyses

The owners of facilities should be responsible for needs analys and condition assessments, developing an ongoing set of tools an processes. Federal and state guidance in methods and standard can be helpful, but the owners should do the actual evaluatio themselves. They may need assistance the first time. The brid survey was successful because it was conducted under a federa state-local partnership. The federal government provided 100 pe cent of the funding for the survey, but the work was done at sta and local levels. The kind of partnership and the ratio of fundi may differ for other facilities, however, such as water systems. Th important point is to involve those who must use the informatio in its development.

Cost is an important consideration in needs assessment. Loc governments must be convinced that the benefit to them in im proved decision making is worth the cost of finding out the conditio of their facilities. They are more likely to understand the value needs assessment if they help produce it and use it in maki decisions.

Guidance from higher levels is also a key concept. One importa consideration is the use that may be made of aggregated data fro

local sources at the state or national level. Where they may be used to develop formulas for the allocation of funds to the states, as in the case of funding for bridge replacement, it is important that the data be both reliable and comparable across jurisdictions. Needs studies that are driven wholly by federal programs may distort the problem at the local level, however.

National Versus Local-Level Data

The idea that the collection of data should necessarily make for better decisions was challenged, particularly for data at the national level. A major use of the national bridge survey data is to facilitate decisions on resource allocation among the states. At the local level, however, the data are more useful in planning, and most of the necessary data are available at the local level. They are not always good, but there are no magic solutions to the information problem of telling managers what they need to do. Planning, to be effective, should be on a relatively small scale and within the scope of what can be done.

National inventory data, it was argued, are of questionable value. Some went so far as to characterize national inventories as a waste of money. The collection of data at the local level should be designed to facilitate local decisions. The process should be one that proceeds from the bottom up and ought not go overboard in the collection of information for its own sake.

It was pointed out that the majority of decisions by public works directors are made in a continuing, incremental process. Most of them want to improve the process and the quality of the data they use. The acid test of the utility of condition and needs assessments or inventories is whether they help elected officials in making a case for facility improvements and maintenance.

Inventories are often used primarily to justify federal or other funding for projects. We should move from inventories to planning, including a consideration of whether all the infrastructure we have in every city is necessary.

Interim Assessments

The bridge inventory took 5 years to complete. Underground systems are far more difficult to inspect and assess. A critical question involves interim assessments. Many cities already have reasonably

good information on their experience with breaks and pressure problems in water mains or sewers. Most could improve their ability to establish priorities by relatively simple computerized manipulations of these data and could improve their access to the information already obtained, which could be used as a springboard to a more comprehensive inventory system. There is, of course, a wide spectrum of capability. Some cities, such as Houston and New York, keep track of their experience and use it to set program priorities. Others record nothing. The important thing is to use the information on experience that is available to avoid having to use rules of thumb, such as replacement cycles, as a basis for capital improvement planning and programming. A city can get away from generalized numbers and rules of thumb by looking at its own experience.

Data Available for Needs Assessments

A lot of information is available. The federal surveys of needs for various facilities, for instance, produce a great deal of data at the state level.

The important consideration in developing a local data system is to build as much as possible from the bottom up, while developing and using common instruments and tools. The federal government could contribute most by developing tools for use by local government, in contrast to mandating that certain data be collected. Needs should be defined in terms of the mission of the agency and the purpose of a facility, rather than in terms of a checklist mentality. This can help identify facilities that are no longer needed, suggesting the wisdom of bringing the assessment process into a broader planning process, in contrast to the planning process required by Section 208 of the Clean Water Act (P.L. 92-500), in which building came before planning. Planning involves stating the mission and getting agreement on it.

The notion of using comprehensive planning as the context for assessment was challenged, however, on the ground that planning often is not a useful process for those who must make capital investment decisions. Data, it was asserted, are not useful to anyone other than those for whom they are collected. It is important to develop data that get politicians to pay attention to a problem. A comprehensive plan does no more than address the needs of a particular set of decision makers. The task of getting together all the

knowledge about a problem in one place for a single decision maker is futile. A more realistic goal is to provide specific information to particular decision makers.

In response, the Wisconsin local planning process, involving the development of an annual and a 5-year capital program, was cited as a workable planning system. It was asserted, however, that capital programs were frequently changed and that projects proposed for the last years of any program do not resemble what is eventually built. It was pointed out that a working capital improvement process contemplates changes in the program in light of events and new information and therefore must be a continuous process. It is critical to have the key decision makers involved in the capital budgeting and programming process.

One participant suggested that the best argument in favor of planning is the way decisions are currently being made. In planning it is important to create and discuss multiyear financial scenarios so that choices can be clarified for those who must make the financial decisions.

The idea that all participants—professionals, citizens, and elected officials—will agree on the same information and its meaning is utopian. All information is self-serving and should be. Not everyone has the same role in the process.

The Quality of Engineering Knowledge

Need is not an absolute quality but is often in the eye of the beholder. Infrastructure problems may be satisfied in some instances by more efficient operation, upgrading performance instead of building better or rebuilding. In other cases, allowing further deterioration of a facility may be more logical than repairing or replacing it. Professionals should make the alternatives and the risks involved in these choices more explicit for the political decision makers, understanding that the professional's "best choice" may not be the decisive one, as the political process has the final say. Early on the engineers need to make their own assumptions, develop possible alternatives and their risks, and clarify the tradeoffs to give the public an opportunity to make decisions.

3

Financing the Nation's Infrastructure Requirements

George E. Peterson

INTRODUCTION

To many governmental bodies the infrastructure financing problem consists of finding enough money to pay for the repairs and new investments they believe are necessary. In this it resembles the unemployment insurance financing problem, the welfare financing problem, and the school financing problem. There seems to be an iron law of government that estimates of spending needs always outrun available financing and that public officials must spend much of their time straining to bring program budgets into balance.

This chapter does not devote much attention to identifying new resources or creative financing techniques that local governments might tap. Rather, it looks at the national system for financing infrastructure investment. Where has it failed, if indeed it has failed at all? What principles should the country follow in paying for repairs, and what institutions are most consistent with these principles?

From a financial perspective, the infrastructure dilemma that has beset the country is simply stated. State and local spending for infrastructure purposes appears to be fixed on an erratic but persistently downward path. The country is approaching the point at which, in the aggregate, it will barely hold constant its net infra-

structure assets. Since public capital expenditures still include a large number of new projects—new mileage for the interstate highway system, for example—net disinvestment, perhaps of substantial size, is occurring in the infrastructure assets that already are in place.

In this chapter I first scrutinize the evidence regarding decline in capital investments in infrastructure. I consider whether the record is what it appears to be and whether there has been significant underinvestment in the nation's public facilities.

If significant underinvestment has occurred, it in turn implies some type of failure in the infrastructure financing system. I first consider the two major sources of financial capital for spending on infrastructure: federal aid and long-term borrowing. Both of these mechanisms have been assailed of late for failing to channel the needed resources into investments in infrastructure.

Another possibility is that public investment is simply being squeezed out of government budgets by competition from other public spending. Government spending decisions may have been distorted by the short-term preoccupations of public officials laboring under fiscal duress. Or the public may be hampered in its spending choices by a lack of information regarding either the condition of existing facilities or the consequences of deferring repairs and maintenance. It is also possible that the electorate, through its public officials, has purchased just the mix of public services that it desires. Despite expert opinion that there has been underinvestment in public facilities, the public may have decided that, given the choices available, it prefers to make do with the physical facilities it now has and accept some deterioration in them. The middle section of the chapter attempts to distinguish between these explanations of the decline in public investment in infrastructure.

Looking to the future, I then discuss three principles that appear applicable to the design of an infrastructure financing system. First, wherever economically and administratively feasible, user-cost pricing should be exploited to finance infrastructure improvements. Such pricing can match investment levels with economic demand, ensure a stable revenue source for future maintenance and repairs, and recover costs from those who benefit from a facility's use.

Second, any major federal financing initiative must draw its justification from the underinvestment and undermaintenance of facilities in past decades. There is no persuasive case for deepening the long-run subsidy for public spending on infrastructure facilities,

but the nation today confronts an investment backlog created by past behavior. Some of the catch-up costs are appropriately spread over taxpayers at large, rather than assigned exclusively to today's users. Which elements of the infrastructure system stand most in need of catch-up spending will differ greatly from one location to another, as will the type of investment required. That situation argues for great flexibility and decentralization in the design of a financing initiative.

Third, any newly created financial institution should use its financial leverage to achieve better management of physical facilities. Paradoxically, the greatest value of a new financing institution may lie not in the financial help it provides, but in the opportunity to extract, in return for financial assistance, a permanent commitment to better assessments of the condition of public facilities, better capital planning and budgeting, and wider application of full-cost user fees.

A last introductory word. Throughout the chapter the reader may find it helpful to keep in mind the distinction between paying for infrastructure in the sense of raising capital to finance investment in it and paying for capital in the sense of bearing the economic costs of a facility. Confusion of these concepts has plagued many a discussion of infrastructure financing.

In the long run, there are only two choices as to who will bear the economic costs of infrastructure improvements: the users of facilities or taxpayers in general. There are, of course, further subtleties of cost incidence. By failing to maintain or replace old facilities, the current generation of taxpayers can shift part of the costs to a future generation. Under some conditions, users of facilities will be able to pass on their user costs to the consumers of final goods and services. But we should remember that federal grants, bond issues, and most other methods of finance do not pay for capital investment in an economic sense; they merely create a general tax burden or a debt obligation that must be extinguished.

THE CURRENT INFRASTRUCTURE FINANCING SYSTEM: HAS IT FAILED?

The most common indictment of the nation's infrastructure financing system is that, over the last two decades, it has generated too little capital investment (CONSAD, 1980; Morgan Guaranty, 1982; Peterson, 1978; Schneiderman, 1975).

The concept of underinvestment is an elusive one. It requires reference to a standard of how much investment should take place. Since there is no such standard, most observers have limited themselves to pointing out the great declines that have occurred in state and local spending on infrastructure. Coupled with engineering observations indicating that the condition of at least some important classes of facilities has deteriorated, the decline in public spending suggests (but does not prove) that there has been underinvestment—certainly in the sense that most "experts" believe that more should have been spent, but also in the sense that a fully informed electorate, faced with an understanding of the true costs and consequences of different investment levels, would have chosen to spend more on the preservation of facilities.

How conclusive are the signs of declining public capital formation? One readily available measure is the rate of new investment or gross capital formation. Almost all public investment in infrastructure is carried out by state and local governments.[1] Although the standard data sources for state and local spending differ somewhat in their definitions and historical series, most point to the same conclusion. State and local capital spending in real terms has declined erratically but steeply since 1968. Table 3-1 provides one measure of this downward trend, for total capital spending on structures and equipment.[2]

More extreme and more persistent than the decline in real spending has been the decline in the share of state and local budgets devoted to capital investment. Recently capital investment has

[1] One other important source is the mandatory facilities that communities require private residential developers to install and turn over to public-sector ownership. See Peterson (1978) for estimates of the aggregate level of such activity. For the special case of California, where these requirements have been especially important, see Kirlin and Kirlin (1982).

[2] There is room for a good deal of discretion in using statistics on capital spending. The data in Table 3-1 are deflated by a special price series that the Bureau of Economic Analysis (BEA) has constructed for state and local capital spending. If capital spending were deflated instead by the general nonresidential construction price index, it would follow a flatter path. A significant share of the measured decline in state and local real capital spending has its origin in the special price inflation that has affected the sector's capital purchases. This, in turn, may be connected to the state and local sector's management of construction work.

As measured by the Bureau of Economic Analysis, capital investment in structures has fallen off much faster than capital investment in equipment. Those who want to dramatize the decline in state and local capital expenditures therefore tend to measure capital for structures only and to report real spending as deflated by the BEA special price index.

TABLE 3-1 Trends in State and Local Capital Expenditures

Year	Gross Capital Investment (billions of 1972 dollars)	Percent of Total Expenditures
1960	21.8	27.1
1965	29.6	26.8
1968	36.8 (peak)	25.7
1970	33.2	21.8
1975	31.7	18.3
1976	28.9	16.2
1977	27.3	15.1
1978	28.5	15.9
1979	26.9	15.5
1980	26.8	15.3
1981	24.9	14.4
1982	22.2[a]	12.9[a]

[a] = preliminary estimate

SOURCE: Gross Capital Investment figures from Bureau of Economic Analysis (unpublished). Total expenditures from National Income and Product Accounts, Table B-77, *Economic Reports of the President* (Feb. 1983).

claimed half or less of the budget share that was customary in the mid-1960s. The social programs of the Great Society appear to have displaced some of the traditional responsibilities that these governments performed.

Of course, not all declines in spending are to be lamented. It can be argued that outlays for school construction were too slow to be cut back in the face of public school enrollment declines. The slowdown in capital spending for roads and highways reflects in part the completion of the greater part of the interstate highway system—as well as a painfully slow recognition of the need for repair of the parts already built.

The national income accounts also attempt to measure capital consumption or the depreciation of existing infrastructure assets. Different types of facilities are assigned different useful lives, on the basis of professional rules of thumb regarding their service expectancy. Annual depreciation rates are calculated by assuming that facilities wear out at a uniform rate over their assigned lifetimes. Applying these annual depreciation rates to the value of the facilities in place yields an estimate of annual capital consumption. This capital consumption can be subtracted from new capital in-

vestment to estimate net capital formation, or the rate at which society is adding to its public infrastructure.

A calculation of this type is necessarily imprecise. There is not enough experience with some types of infrastructure, like water and sewer lines, to form a reliable judgment of expected lifetimes. For other systems, like roadways, we know that depreciation does not proceed linearly but accelerates as the road surface reaches the end of its scheduled life (Eckrose, 1979). Nonetheless, these estimates provide a good general index of the rate of additions to the nation's infrastructure. They are much more meaningful as an aggregate index of investment in infrastructure than as a guide to decisions about repairing or replacing individual pieces of it.

Figure 3-1 shows the course of net investment by states and localities in structures (excluding equipment), which has fallen off much more precipitously than has gross investment. The difference is due to the accumulation of older structures subject to depreciation.[3] The rate of net addition to state and local structures has now almost reached zero. An extrapolation of the recent trend would find the country disinvesting in public assets, on balance, starting in 1983 and using up its inherited infrastructure at an ever-faster rate as it moves into the future. A parallel conclusion holds for some of the principal components of the infrastructure inventory, such as roads and highways and school buildings.

One may quarrel with some of the procedures used by the Bureau of Economic Analysis in making these estimates. The exact location of the point of "zero net investment," for example, remains unknown. But such quarrels should not obscure the direction of net investment trends or their emphatic character.

The statistical argument for more infrastructure investment bears some resemblance to the statistical argument for greater defense spending or greater private investment. Just as the sustained decline in real outlays for defense and the share of the federal budget devoted to defense through 1980 established a presumption in favor of greater defense spending, so does the decline in real infrastructure spending and the decline in the share of state and local budgets expended for this purpose. In neither case are spending trends alone the best evidence. The apparent lag in infrastructure investment

[3] Structures are also the category of capital spending that has suffered the most severe decline in gross investment (see note 1).

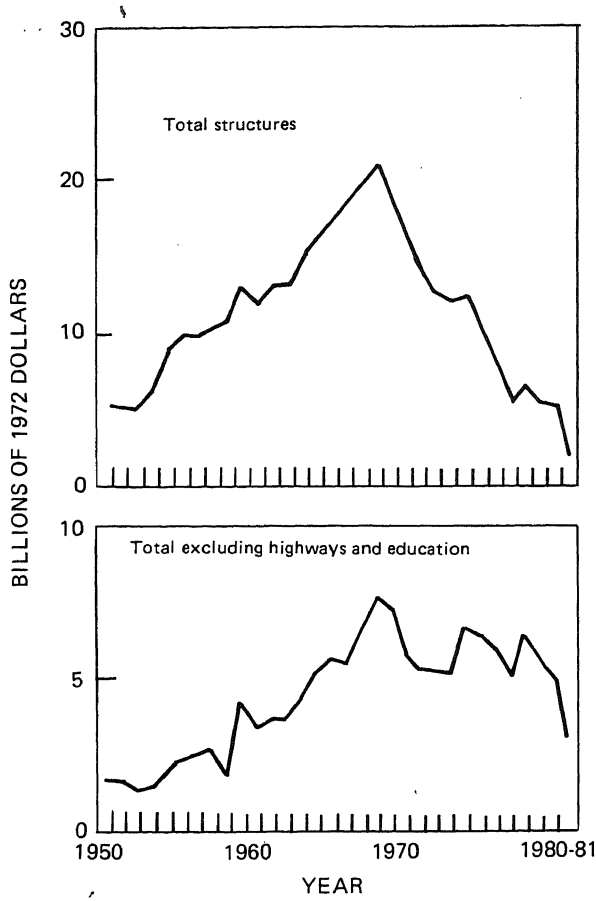

FIGURE 3-1 Net investment in structures by states and localities. SOURCE: Data from Bureau of Economic Analysis. Figure from "Rebuilding America's Infrastructure," *The Morgan Guaranty Survey*, July 1982.

needs to be checked against the condition and performance of public facilities. We have undertaken this task elsewhere (Peterson et al., 1983); it suffices here to note that condition assessments point to a moderate deterioration of facility condition and performance in recent years for several categories of infrastructure and to no decline in others. This record is better than one might anticipate from the aggregate investment trends and far better than some of the apocalyptic estimates of capital needs would imply. It seems probable that earlier generations bequeathed us a capital plant that was more durable and more resistant to temporary neglect than our standard accounts assume.

CAPITAL FINANCING INSTITUTIONS: ARE THEY AT FAULT?

If there has been significant underinvestment in public capital assets, it would seem that some part of the nation's system of capital financing or capital budgeting must be at fault. A common assertion holds that one or more of the traditional sources of capital financing has simply ceased to perform its role of channeling capital to infrastructure investment. The logical culprits are the two most important sources of financial capital—federal aid and long-term borrowing.

Federal Aid

Federal aid to state and local governments for investment in infrastructure presents a mixed picture (see Table 3-2). Since the mid-1970s, federal assistance has been the principal engine of whatever growth (in nominal dollars) there has been in state and local capital spending. The federal share of specifically subsidized capital formation did not change much over the period 1960-1975, then increased at the same time that total spending (in real terms) was on the decline. Starting in the first half of the 1970s, funds from

TABLE 3-2 Federal Capital Aid

Year	Total Capital Investment (billions of current dollars)	Federal Capital Aid (billions of current dollars)[a]	Federal Capital Share (percent)[b]
1960	13.5	3.3 (3.3)	24.4
1965	20.1	5.0 (5.0)	24.9
1970	29.1	7.1 (7.1)	24.4
1975	42.4	10.9 (8.5)	25.7 (20.0)
1980	54.6	22.5 (18.7)	41.2 (34.2)
1981	55.4	22.1 (18.4)	39.9 (33.2)
1982	54.0	20.2 (16.7)	37.4 (30.9)

[a]Figures in parentheses exclude Community Development Block Grants; only a small portion of these funds have been used to finance spending that is classified as state and local capital investment in this table. Both figures in this column exclude general revenue sharing funds expended on capital formation.

[b]Figures in parentheses exclude Community Development Block Grants.

SOURCE: Total capital investments from Bureau of Economic Analysis (unpublished); federal capital aid from Special Analysis D and Special Analysis H of *U.S. Budget* (fiscal 1984 and earlier years).

general revenue sharing also found their way into local capital budgets. Toward the end of the period, special public works grants were installed as a federal antirecession tool and used to fund infrastructure repairs.

Since 1980, capital grants to state and local governments have been cut back, as have other types of grants-in-aid. The Reagan administration originally announced its intention of reducing future capital assistance to state and local governments far more drastically. Since 1982, however, the course of federal capital aid has been reversed somewhat. Passage of the gasoline tax bill will boost highway and mass transit aid by about 50 percent between fiscal 1982 and fiscal 1984 and lead to a projected 17 percent increase in all federal capital assistance to state and local governments between fiscal 1983 and fiscal 1984.

Whatever the cause of the slowdown in state and local capital spending, it seems unfair to pin responsibility on inadequate growth in total federal assistance. Over the period 1975-1980, federal capital aid was growing in real terms at the same time that state and local expenditures from their own resources were rapidly declining.

A better case can be made that the nature of federal assistance has been ill-suited to the long-term needs of states and local areas. For one thing, federal aid has followed an erratic off-again, on-again path. Adoption of the construction grant program of the Environmental Protection Agency (EPA) was followed by Richard Nixon's attempt to impound capital funds, then a period of rapid growth in federal funding, and finally legislation that cut back sharply on the federal aid commitment. The experience with special public works programs has been even more volatile. The obviously temporary nature of these 100 percent federally funded programs caused state and local governments to postpone or cancel their own capital spending in anticipation of the receipt of federal dollars. One study concludes that the net effect of federal public works grants was to depress state and local capital spending and to cause the postponement of as much as $22 billion in capital expenditures (Gramlich, 1978), although this estimate seems implausibly high.

It is the short-term horizon of most federal assistance programs and their instability that have damaged state and local capital budgeting, not an inadequacy in funding levels.

Federal assistance, too, has been slow to reorient itself toward repair of existing capital facilities. Until 1976, the use of federal highway funds for repair or rehabilitation of the interstate highway

system was prohibited. Although recent highway legislation rectifies this bias to a considerable degree, the greater part of federal aid continues to be tilted toward new projects. The new clean water legislation, for example, eliminates repair of old sewer lines as a category eligible for federal assistance. This federal posture does not reflect a lack of awareness of repair needs, but rather the conviction that ordinary repair and replacement of existing facilities is a local responsibility that should be locally financed.

Long-Term Borrowing

If state and local governments have chafed at federal capital aid policy, they frequently have been on the verge of offering a requiem for the long-term bond market. Tax-exempt interest rates have suffered violent swings over the last decade. At the height of the interest-rate cycle, in 1974-1975 and again in 1980-1981, the use of long-term borrowing by state and local governments for infrastructure financing withered away (see Table 3-3).

Until recently it appeared that the most recent swing in interest rates and infrastructure borrowing might presage a permanently altered capital financing market for infrastructure. In 1980, for example, state and local governments borrowed for infrastructure investment purposes an amount equal to less than 18 percent of their reduced investment levels. This was an all-time low and contrasts with a historic share of well over 50 percent bond financing. On top of the discouragement offered by high interest rates came public resistance to approving general obligation bonds in bond elections. Many commentators forecast that the general obligation bond, the historic financing vehicle for multipurpose infrastructure investment, would be virtually phased out of the capital market. A look at Table 3-3, treating 1980 or 1981 as the final reporting year, seems to reveal an ominous decade-long deterioration in the ability of long-term borrowing to meet capital investment requirements.

In today's perspective, matters look much more encouraging. State and local borrowing rebounded to unprecedented levels in 1982, for infrastructure investment as well as for other purposes. The 1979-1981 period now appears as largely a cyclical phenomenon, albeit an extreme one, not the prelude to a new capital financing era. Some of the fall-off in long-term borrowing during 1979-1981 was offset by a surge in short-term borrowing, as states and localities tried to avoid long-term commitments to unprecedentedly high in-

TABLE 3-3 Long-Term Borrowing as a Share of Total Capital Investment 1970-1982 ($ billion)

Year	Total Capital Investment ($)	Long-Term Bonds Sold (Less Refundings) (TCI) ($)	(Less) Nontraditional Uses of Bonds ($)	Total Long-Term Borrowing for TCI ($)	Long-Term Borrowing as Percent of TCI
1970	29.1	18.0	1.3	16.7	57.4
1971	30.1	24.4	4.3	20.1	66.8
1972	31.6	22.0	3.1	18.9	59.8
1973	36.2	22.2	4.7	17.5	48.3
1974	42.7	22.9	4.2	18.7	43.8
1975	42.4	29.6	8.8	20.8	49.1
1976	40.8	32.2	11.6	20.6	50.5
1977	40.8	37.9	16.8	21.1	51.7
1978	47.2	39.3	20.3	19.0	40.2
1980	54.6	46.3	36.5	9.8	17.9
1981	55.4	46.4	33.1	13.3	24.0
1982	52.2[a]	74.9[a]	44.4[a]	30.5[a]	58.4[a]

[a] = preliminary estimate

NOTE: Nontraditional borrowing is defined as borrowing for housing, hospitals, industrial development, student loans, and pollution control. In addition, for the purposes of this table, public power is also included because privately owned public power facilities are not included in BEA's definition of state and local capital investment.

SOURCES: Data: Total Capital Investment, from Bureau of Economic Analysis, unpublished, calendar year gross fixed state and local capital formation.

Bond Issues: Public Securities Association and *Weekly Bond Buyer*. Table compiled by the General Accounting Office.

terest rates. Some of the fall-off in new borrowing was made possible because states and localities used up their accumulated bond funds. Just as state and local governments in 1979-1981 converted into physical capital investment the bond funds they had borrowed earlier, so in 1982 they replenished their depleted cash reserves and even took advantage of lower interest rates to borrow ahead of investment needs. By the third quarter of 1982, state and local governments had bought almost $19 billion of Treasury debt with the excess cash they had from long-term borrowings. This amount was nearly twice as high as purchases in any full year in the previous decade.

For now, financing availability is not an effective constraint on state and local capital investment. In fact, the excess cache of long-term borrowed funds that governments have on hand raises severe questions as to whether a further infusion of capital funding, from

a temporary federal public works program, could have the stimulating effect on capital construction that is desired.

Even the general obligation bond has enjoyed a modest renaissance. In the November 1982 bond elections, the highest percentage of bond proposals since 1967 was approved by the electorate (86.7 percent). Many of these bonds were proposed specifically for infrastructure repair financing and were described that way to the voting public.

In sum, the long-term bond market has not failed as a source of infrastructure finance. Proposals to create new capital financing institutions cannot be rationalized on the grounds that the old institutions have proved unable to provide the long-term investment capital that states and local areas need.

It is true that problems remain in the tax-exempt bond market. The gap between tax-exempt and taxable interest rates—the savings that states and local areas gain from having access to tax-exempt borrowing—remains near its all-time low. In part this can be attributed to recent changes in the tax laws, which have made the holding of tax-exempt securities less attractive to commercial banks, casualty insurers, and individuals.

In greater part, the narrowing interest rate advantage of tax-exempt bonds can be ascribed to a surge in nontraditional borrowing. The bond market has become flooded with housing mortgage bonds, industrial development bonds, pollution control bonds, and bonds for private hospitals. These uses now account for over half of all tax-exempt bond issues. The volume of supply has placed pressure on tax-exempt interest rates and has also raised a question of priority for state and local governments. If state and local governments supported rather than opposed restrictions on single-family mortgage bonds and industrial development bonds in order to help preserve borrowing rates for infrastructure investment, their pleas to the federal government to acknowledge the paramount demands of infrastructure financing would be easier to accept at face value.

Insulating Infrastructure From General Budget Competition

The possible failures of infrastructure financing considered thus far are failures of the mechanisms that supply financial capital. Another possibility for failure occurs in the capital budgeting process. Under intense budgetary pressures, public officials may find

it easiest to effect spending reductions by deferring maintenance, skipping repairs, or postponing capital investment.[4]

To some degree, this singling out of the capital budget for temporary cutbacks may represent rational behavior. For many capital systems, maintenance and replacement can be deferred for a time without significant damage, as long as the appropriate schedules are later resumed. The danger of temporary deferrals lies more in the precedents they establish. Temporary postponements of repairs tend to stretch into permanent neglect, and lengthened replacement cycles can gradually become customary practice.

The capital budgeting failure that is alleged goes beyond these temporary adjustments and has its origin in a perceived political imbalance. Budget reductions that trigger employment layoffs, wage freezes, or cancellation of public services meet immediate and vigorous opposition. At least in the past, maintenance deferrals and cancellation of underground capital projects have been much less visible to the electorate. Their consequences typically will not become apparent until some years in the future.

It would be difficult to maintain that any trend as prolonged as a two-decade diminution of capital spending for all state and local governments could have its explanation in a series of fitful, emergency budget cutbacks. However, the tendency to single out the capital budget for cuts during fiscal crises is apparent from the two graphs of comparative spending, for Cleveland and New York City, shown in Figure 3-2. In both cases, while the current city budgets were being reduced amid great publicity, capital budgets were under far more severe attack. The subsequent turnaround in capital spending in both cities is to a great degree a result of public discovery of the size of the backlog of infrastructure investment that had been created.

New York City and Cleveland are admittedly two very extreme cases. However, the same pattern of a sudden collapse in infrastructure spending at a time of budgetary pressure can be found in Boston, Buffalo, Oakland, and other cities that have had to wrestle with serious budget problems.

The diagnosis that in fiscally burdened governments at a time of budget pressure capital spending and maintenance cannot compete effectively with other budget claims has led to efforts to remove

[4] For systematic evidence that capital and maintenance spending is, in fact, the most vulnerable budget item under fiscal pressure, see Wolman and Peterson (1981).

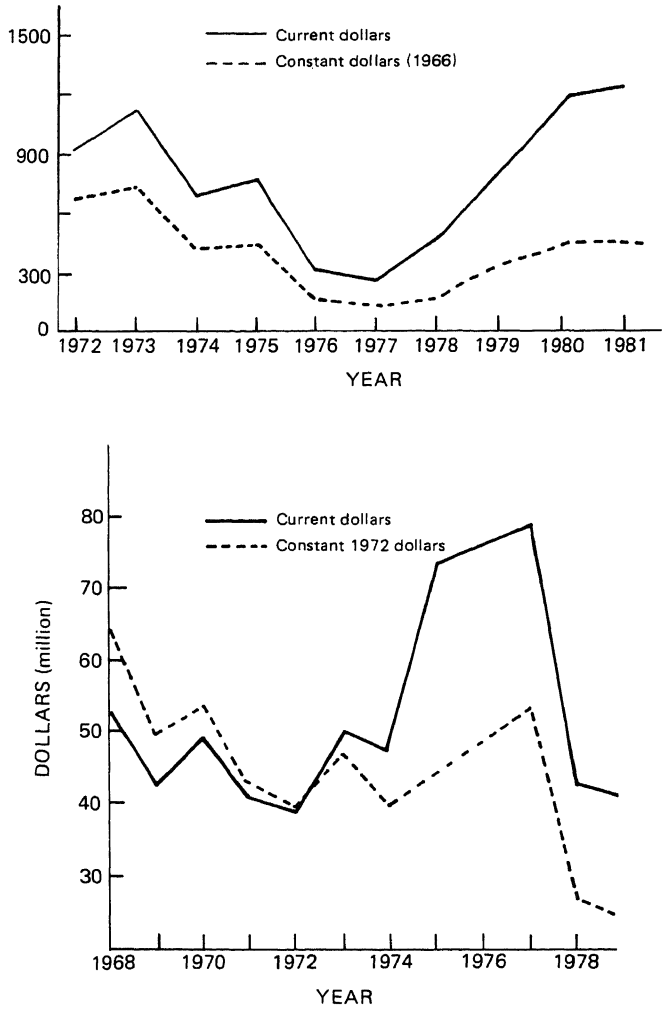

FIGURE 3-2 Capital construction awards in New York (above) and Cleveland (below).

capital spending decisions from the general budget. One device for achieving this end is the dedication of special revenues, so that they are used only for designated capital purposes. The dedication of revenue sources is intended to insulate capital spending from the vicissitudes of political budget choice. If a capital spending function has the good fortune of being tied by dedication to a rapidly growing revenue source, it has the additional advantage of guaranteed future spending growth.

At the federal level, the most important sources of dedicated capital revenues are the highway and airport trust funds. At the local level, the use of dedicated capital revenues is most common in systems supported by user charges. But other types of revenue dedication are gaining momentum. In persuading the local electorate to support a municipal income tax increase, the City of Cleveland dedicated half the proceeds to paying off debt and rebuilding the city's capital plant. The Cleveland business community assumed leadership in the tax increase campaign, once it was assured that revenues would be used for long-term capital purposes. Many other cities have introduced proposals that would dedicate selected revenue sources for capital maintenance or for repayment of future infrastructure-related debt.

To strengthen the effectiveness of revenue dedication, several cities have gone one step further and tied revenue change to institutional reorganization of the responsibility for infrastructure management and financing. When the City of Boston spun off its sewer and water operations to an independent authority, the legislation creating the authority formally dedicated revenues to use within the sewer and water system. The enabling legislation also requires that 5-year capital budgets for system improvements be prepared and that user fees be set at a rate sufficient to finance the capital investment plan.

In Cleveland, a legal suit has been used to establish budget priority for water system investment. The suit was brought against the city by suburban communities on the grounds that the city's failure to adequately maintain the water distribution system was wasting an asset of crucial importance to the entire region. A local judge ordered the city to surrender ownership of all water assets to a new regional authority. Only under the threat of this court order did the city and suburbs reach legal agreement on a capital reinvestment plan under which the city would retain ownership of the water system but commit itself to carrying out some $800 million of capital improvements on it. The legal obligation to carry out this investment has brought an urgency to capital budgeting that formerly was missing.

Efforts like these seek to remove the capital financing decision from the ordinary realm of political debate. In effect, they acknowledge that infrastructure investment cannot compete equitably with other budget claims and seek to substitute expert analysis, man-

datory court orders, or revenue dedication for the uncertainties of political budget choice.

There is little doubt that these various devices have succeeded in boosting public capital spending and stabilizing capital financing. Whether the institutional fragmentation they have spawned and the removal of larger and larger portions of the capital budget from general taxpayer control will be desirable over the long run is difficult to know.

FINANCING PRINCIPLES: THE USER-COST PRINCIPLE

What principles should guide us in designing a national infrastructure financing system of the future? One principle is the application, wherever possible, of user fees. User fees establish an analog to the private market, where prices are set and users pay according to the size of their service consumption. When applied to capital infrastructure services, user-cost pricing has some signal advantages.

The user-fee structure itself helps to regulate capital demand. Estimates of capital financing needs, both for the nation as a whole and for individual localities, now run so high that it is inconceivable for them to be met in full. Under these conditions, it only makes sense to enlist the financing mechanism itself in demand restraint. The fact that users must pay for the use of a facility limits their demand for it and reduces the physical capacity necessary to satisfy demand.

User fees set to recover the full incremental costs of facility usage have been shown to effectively limit demand and enhance economic efficiency in water supply and distribution (Gilland and Hanke, 1982), airport construction, wastewater treatment, and many other areas of capital infrastructure.

Many cities employ user fees in the form of special assessments explicitly to frame demand for capital improvements. The City of Milwaukee's streets department, for example, annually measures street surface condition and proposes those streets in worst repair for resurfacing. Since street resurfacing is financed by special assessments on abutting landowners, however, these owners have the final say in deciding whether capital investment is carried out. This contrasts with the city's practice of selecting major arterials for resurfacing based solely on professional judgment about the need

for upgrading. The benefits from such improvements extend well beyond adjoining landowners and hence improvements are not financed through special assessments or subject to local property owners' referenda.

Of less theoretical benefit but of equal practical advantage in the eyes of many public capital managers is the fact that the revenue stream generated by the sale of capital facility services can be easily segregated and dedicated to facility reinvestment. The prospect of a reliable revenue stream makes it possible to issue revenue bonds to finance the initial capital costs of a project.

For cities that stand in need of debt relief or major infusions of capital, user-cost pricing holds forth another possibility. Once a full-cost pricing policy is adopted, including allowance for capital replacement or "profit," the system's fixed assets take on an economic value. They then can be recapitalized or sold. When the City of Boston spun off its sewer and water system, the independent authority absorbed all of the city's debt for the system and made a one-time cash transfer to the city as well. Suffolk County, New York, is in the process of attempting to transfer legal title and tax depreciation rights to a part of its county sewer system to a consortium of private investors, in return for which it will receive a payment of several hundred million dollars.

The scope for employing user fees in meeting capital demands can be illustrated by the nation's water system. The President's Intergovernmental Water Policy Task Force (1980) estimated in June 1980 that 87-90 percent of the water supply and distribution investment needs it projected would be met with rate increases no greater than twice current rates. Rate hikes of this magnitude are politically explosive and may require institutional reorganization to accommodate, but, given the current rate structure in most cities, they do not impose an unrealistically stiff financial burden.

FINANCING PRINCIPLES: AN INFRASTRUCTURE BANK

The nation's current infrastructure financing policy incorporates three clear principles as well as one that is not so clear.

First, federal aid is provided to support capital spending on infrastructure facilities that are national in coverage or where capital investment is necessitated by the establishment of new federal standards. The interstate highway system and major hub airports are good examples of facilities in the first category; EPA construc-

tion grants for wastewater treatment plants are the best example of facilities in the second category.

Second, user-fee financing is used to finance improvements to facilities where fees are economically and administratively appropriate. Reliance on the fee structure is by no means universal, even in these cases, but the principle of user fees and revenue bond financing is now generally accepted.

Third, state and local general tax revenues and general obligation borrowing are used to pay for remaining general-purpose infrastructure facilities. The ongoing repair, improvement, and maintenance of local water distribution systems, sewer collection systems, schools, parks, and other facilities are recognized in principle as local financing responsibilities, although state governments (and to a minor degree the federal government) sometimes offer financing assistance to offset inequalities in local revenue-raising capacity.

The element of uncertainty concerns the financing of large-scale investments needed to discharge repair and replacement backlogs inherited from past neglect of primarily local facilities. Such facilities do not fit easily into any of the financing categories. Although the benefits of capital spending are primarily local, the magnitude of investment required may greatly exceed the expenditure that would normally be required to maintain and replace local capital systems if there had been a history of adequate care. There is no clear reason why today's users of these facilities should bear the costs created by the previous generation's violation of the implicit social contract that each group of users passes on to the succeeding one a capital plant in basically good repair.

Current federal financing policy reflects the uncertainty of this principle. There is a large federal commitment to repairing or replacing major bridges, even when these carry benefits principally to local users. The expense involved in requiring local taxpayers to absorb these costs has appeared unreasonably great. The federal bridge repair and rehabilitation program represents a federal commitment to assist in one-time, catch-up investment. However, there is no comparable federal program for assisting in catch-up investment necessitated by decades of depreciation of water or sewer lines or other types of facilities.

It is the challenge of finding efficient and equitable ways of financing today's backlog of infrastructure investment that suggests the creation of a new financing institution. Such an institution

should be designed as well to overcome the most conspicuous defects of the present mix of financing arrangements. Specifically, it should:

- Provide a stable, long-term financing source to offset the instability of both federal aid and the bond market.
- Use its financial resources to institutionalize new capital management and maintenance practices. The value of one-time, catch-up investment will be wasted if the nation's infrastructure facilities, once in better condition, are turned back to the same ineffective arrangements that allowed them to deteriorate.
- Use its financial resources or leverage to establish long-term user-fee financing of capital assets wherever possible.
- Link capital financing more effectively to capital planning by requiring recipients to generate their own assessments of capital condition, long-run capital investment and maintenance requirements, and immediate investment priorities.
- Allow states and local governments flexibility in deciding what the local priorities for catch-up investment are. These priorities cannot be established uniformly at the federal level.

One institution that meets these requirements is a federal infrastructure bank linked to a series of state infrastructure banks. These banks would make below-market loans for infrastructure repairs and perhaps other infrastructure investments. Upon repayment of the loans, the funds would be recycled to other capital projects.

One of the attractions of an infrastructure bank is that it represents a long-term commitment to dealing with the capital infrastructure dilemma. It is an implicit guarantee of permanent attention to public capital needs. Once a bank has been created and endowed with a professional staff, it is unlikely to disappear. Loans will have to be repaid and the bank will have to be there to receive them. If the initial legislation establishes a revolving fund, so that loans that are repaid are recycled to new infrastructure users, a second generation of lending activity can be ensured.

Permanence, visibility, and professionalism are the critical arguments in favor of an infrastructure bank. It is not that below-market loans to support public capital spending represent a magical or costless source of financing, but rather that an infrastructure bank is a tangible, long-term commitment, more difficult to disavow than a new federal block grant program.

What of the financing requirements of such a bank? To have an

impact on infrastructure conditions, it would have to consolidate some existing categorical grant programs and have an additional capitalization of $10-$20 billion. That represents a large amount of new federal borrowing, given today's budget conditions.

The argument for a new institution of this type would be more persuasive if state and local governments would volunteer to surrender some of their current borrowing capacity in exchange for this new financing vehicle. If infrastructure finance is a priority, these governments might consider or be required to consider offsetting reductions in the volume of tax-exempt debt issued to support middle-income housing mortgages or industrial development.

It would be a mistake to think of the infrastructure problem as one of dollars alone. It is also a problem of institutions. There is little to be gained from boosting investment in the nation's public capital stock unless we can also be certain that, once this investment is carried out, ordinary repairs and maintenance will not again be deferred.

It is essential that federal policy allow local discretion in deciding how any new infrastructure dollars are spent. It is entirely appropriate, however, to have in place the institutions that can guarantee capital preservation. An infrastructure bank, for example, should make loans to a water or sewer system only on condition that the system charge full-cost pricing for its services. User fees should include amounts needed to sustain a long-term capital repair and replacement strategy. At present, too many water systems are disinvesting in their assets simply because they do not have the political will or ability to charge full-cost fees.

The bank may also want to make a condition of loans that the local government have in operation a system of capital assessment and capital budgeting that meets professional standards as established by the bank.

These conditions are no more onerous than those a private bank would require of a private borrower. They help ensure that the loan can be repaid and that the public funds used to subsidize loan rates will serve their public purpose. In fact, the ability to exert institutional leverage of this sort is one of the principal advantages of a bank structure. Paradoxically, the least essential contribution an infrastructure bank may make is the actual financing of the next generation of capital formation. More critical is the leverage it can exert on the nation's institutional capacity to plan and manage capital facilities.

Recent history speaks eloquently that one covenant to a subsidized loan agreement is worth a thousand exhortations in planning articles.

CONCLUSION

The idea that there has been a failure of infrastructure financing and budgeting is often advanced as an explanation for the steep decline in state and local capital spending.

Two of the commonly proffered explanations—that federal aid growth has been inadequate and that the long-term bond market has ceased to provide capital for infrastructure finance—receive very little support from the evidence. A third assertion—that capital infrastructure spending has been unable to compete effectively with other budget claims for political reasons—has greater plausibility, at least for those cities in severe fiscal straits, but it cannot account for the strong secular decline in capital spending.

Most of the explanation for the decline in infrastructure spending would appear to lie elsewhere. It has been a deliberate budget choice exercised by public officials and by voters. The fact that infrastructure bond issues fall precipitously when long-term interest rates climb, that local capital spending is postponed or supplanted when federal funds become available, that communities invest in wastewater treatment plants up to the limit of availability of federal matching funds but not beyond are signs of economic decision making at work.

Government officials and the public make their capital budget decisions without much information. It is possible—indeed, likely—that with better and more plentiful information as to the condition of facilities and the consequences of deferring repair investment, local governments would have chosen to spend more for these purposes. The information generated by the federal requirement for annual bridge condition assessment provides a good example of the spending stimulation created by new information as well as new federal aid dollars.

If the capital financing problem is one of inadequate information, however, the solution to it lies in the collection of better information and more effective communication of it to voters—not new capital-financing vehicles or formal efforts to extricate capital expenditures from a government's general budget.

REFERENCES

CONSAD
1980 *A Study of Public Works Investment in the United States.* Washington, D.C.: U.S. Department of Commerce. Available from the National Technical Information Service, Springfield, Va.

Eckrose, Roy A.
1979 Measuring effectiveness of pavement preservation techniques. *Public Works* (July).

Gilland, E. J., and Hanke, Steve
1982 Crisis: financing water and wastewater. *Water/Engineering and Management* 129(7):41-43.

Gramlich, Edward M.
1978 State and local budgets the day after it rained: why is the surplus so high? *Brookings Papers on Economic Activity* I:191-217.

Kirlin, John J., and Kirlin, Anne M.
1982 Public Choices—Private Resources: Financing Capital Infrastructure for California Through Public-Private Bargaining. Sacramento: California Tax Foundation.

Morgan Guaranty
1982 Rebuilding America's infrastructure. *The Morgan Guaranty Survey* (July).

Peterson, George E.
1978 Capital spending and capital obsolescence. In Roy Bahl, ed., *The Fiscal Outlook for Cities.* Syracuse, N.Y.: Syracuse Press.

Peterson, George E., Miller, Mary John, Godwin, Steve, and Shapiro, Carol
1983 *Benchmarks of Urban Capital Condition.* Washington, D.C.: Urban Institute.

President's Intergovernmental Water Policy Task Force, Subcommittee on Urban Water Supply
1980 *Urban Water Systems: Problems and Alternative Approaches to Solutions.* Washington, D.C.: U.S. Government Printing Office.

Schneiderman, Paul
1975 State and local government gross fixed capital formation: 1958-73. *Survey of Current Business* (Oct.):17-26.

Wolman, Harold, and Peterson, George
1981 State and local government strategies for responding to fiscal pressure. *Tulane Law Review* (April).

DISCUSSION

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I will discuss the peculiar problems of financing large capital investments. We have not always clearly distinguished between ongoing capital expenditures, especially for maintenance, and large projects. Each raises different management and financial issues.

This chapter does a good job of disproving the hypothesis that if we are investing too little there must be something wrong with the financing mechanisms. Both the chapter and experience argue that

the greatest problem for financing capital projects is the willingness of the ultimate payers to pay the price. Public disinvestment has been a fairly deliberate process, whether the public is ill-informed or not. The grant mechanisms and the bond market really are not the root causes of the disinvestment.

I have some problems with the data that are included in the chapter, and those that are used generally. This is an endemic problem because the amount of research on public spending is relatively slight and has always been fairly weak. For example, Table 3-3 can be very misleading. First, it is not clear which long-term bonds are included: general obligation or revenue bonds. Second, it does not take into account the role of rates. One very good explanation for the drop in 1979 in the ratio of long-term debt to total expenditures is the incredible increase in interest rates in that year. Many governments merely deferred projects in that year due to the increase in rates, not because of any general aversion to long-term debt.

The data also leave out the role of short-term debt. Many of the same governments, instead of deferring financing altogether, used short-term debt because they thought rates would be lower in 1980. Almost everyone ended up paying higher rates by using the short-term approach. Looking at only long-term debt leaves out the explosion in short-term financing as governments have tried to avoid the higher long-term rates. Short-term financing, of course, depends on the ability of governments to roll over their debt forever. As the experience of New York indicates, such confidence can be badly misplaced. That city ended with $6 billion worth of short-term debt coming due in one year and found itself, furthermore, with no market access.

In terms of fiscal pressure causing budget cuts, particularly for ongoing maintenance aspects of capital financing, the role of market access cannot be excluded. The reason New York's capital program declined dramatically is because no one would lend it any money. One of the reasons the recovery program for the city had a major capital component was to make it very clear that merely getting the city's past debt taken care of was not enough. It was also necessary to address the problem of needing at least a billion dollars a year for capital.

We normally do not think about the loss of market access for local governments. Traditionally local governments could borrow at a reasonable price. But as we have recently seen, governments

with good credit ratings can lose market access. Not only did New York City lose market access, but also the state lost it for a time, and so did many other local governments that had nothing to do with New York City's financial problems. So, in looking at historical experience, we have to consider the thought that there may be times in which governments simply cannot borrow, regardless of their desires.

I generally agree with the economists that there are a great number of benefits from user fees. There are also, however, some costs. User fees are not tax deductible. Citizens may prefer to tap their subsidy from the U.S. Treasury by deduction of local taxes that support their services and facilities. When we begin to talk about very large user fees, a substantial subsidy is lost.

Beyond some point, user fees may not be financable. It is hard to sell revenue bonds, for instance, where there are free alternatives to the facility in question. Bonds for a toll bridge will not sell if there are good nearby free bridges. If there is any danger that other facilities will be used or that the fees to finance the debt will be so high as to induce use of competing facilities, bond buyers will not take the risk. This means that, for the most part, only essential services are susceptible to user charge financing, particularly where private business cannot provide a competitive service. Where there is no monopoly—and perhaps even where there is a monopoly—the market may be unwilling to accept the agency's view of the demand for use of its facility. Such facts as the sharp downward shift in demand for electricity, for instance, have made the market extremely skeptical of earlier estimates of the need for additional power plants by electric utilities.

Large capital projects should be an area of major concern. There are tremendous risks involved in large, new public investments. These risks have a great impact on the ability to finance them. This can be illustrated by the effort of the Milwaukee Metropolitan Sewerage District to finance and build a $2 billion interceptor project.

The first big problem is the risk of noncompletion. What happens if it does not work or cannot be completed? The experience with the Western Washington Public Power system shows that rate payers do not follow through on "take or pay" contracts. Rate payers seem to see no reason to pay for plants that produce no electricity. A lot of people try not to pay. Anything that engineers are not sure they can finish are things in which bankers are sure they do not want to be involved.

Related to noncompletion is the problem of escalating cost. In Milwaukee all estimates for the interceptor were originally made in current dollars. But bankers want to know what it is really going to cost. This produces big numbers and may result in political opposition.

This raises the issue of loss of public support before completion. The day is past when a project can be slid past the public with the argument that so much has already been spent that it cannot be stopped now. People are increasingly willing to shut down an incomplete project when costs have escalated and public support has evaporated. So rather than avoid the public controversy, it is better to be up front about the costs and let people know all of the problems that may arise.

Another problem is the risk of political mismanagement. Local officials cannot always be depended on to do the right thing. Even with a court order, for instance, it took a year for the Cleveland City Council to increase the water rates to finance capital improvements. Political mismanagement usually takes the form of being unwilling to face up to current dollar costs.

Next is the risk of forecasting and the risk of scale. Rule of thumb estimates of cost ranges are simply not good enough from a financing standpoint.

Last there is the risk of underlying economic viability. Financing depends on the underlying economic strength of the jurisdiction—its ability to pay the bill. Sometimes needs for capital investments simply do not line up with the ability to pay. When that occurs, the only way projects can be financed is through capital grants from other levels of government. Private capital will not rush to those areas.

In facing all of these problems, Milwaukee's financial plan involved a careful analysis of the Metropolitan Sewerage District's strengths and weaknesses and all possible sources of financing. Their weakest point was bonds. There had been an assumption that the entire $2 billion would have to be raised through bond issues—this was simply inaccurate. It was also impossible to market such a large issue without a terrible burden on the member jurisdictions. The task was to increase the amount of cash put into the project and to reduce the amount of debt that had to be financed.

It is no longer going to be possible to capitalize interest out of a bond sale. There is a growing need to put in cash up front and throughout a project to reduce debt service costs. In Milwaukee a

financial plan was developed that in each year used more cash from taxes, grants, and other sources than from bond proceeds. This reduced the amount that had to be borrowed. It also allows for the whole program to be paid for in the last year of capital expenditure—1996. It was easier to sell this shorter payment schedule to the rate payers in a period of high interest rates. The tax rate was brought up in three steps to pay for the entire project, rather than try to drag it out over a long period of time. If costs should escalate, this would require that the new tax rate be held for an additional year.

Not only do we have a problem of maintenance and ongoing capital improvements, but also the large project poses a need for a special type of planning. Financial planners should be involved at the earliest stages of the process to develop schedules and financing plans in the context of local problems and politics, to develop a strategic plan attuned to local circumstances.

Forest Witsman

One issue with regard to spending and financing is whether we have overbuilt some of our facilities. In Sedgewick County, Kansas, we have decided that in some instances we have. Where a paved road serves a single farm, for instance, we are turning it back to gravel, rather than bear the cost of maintaining it as if it were an urban street carrying heavy traffic. In far too many cases we have tried to provide urban services to areas that will not support them.

There have been poor practices with the use of special assessments. Systems were built on the basis of optimistic assumptions, and now local governments are faced with high rates of tax delinquencies. In other cases, governments have not been strict enough with developers in requiring the dedication and construction of adequate facilities for the kinds of subdivisions that eventually are built.

Another area for further investigation with respect to the costs of facilities is the role of unions. Especially in cities that have prevailing wage contracts, labor costs are important considerations in the financing of public works and in operating costs as well. We also need research on the effects of the Davis-Bacon Act on infrastructure costs.

In my judgment the apparent conflict between capital and operating spending is basically a political failure. It raises a question

of political structure, whether the ways we choose and organize ou governments are satisfactory. There are certain commonalities amon the cities that have had the most severe financial problems. Withou making a pitch for the city manager system, I observe that ther are no cities run by city managers on that list.

We have missed an opportunity in our discussion of the Ne Federalism. The municipalities have not raised the issue of wha services are to be provided by each level of government and wh will provide the financing for them. Instead there was a lot of fruit less argument between nineteenth-century liberals and twentieth century liberals over whether particular grant programs should b kept. The important debates of the next 20 years will revolve aroun things like capital. The places that survive will be the places tha can handle shifts from operating to capital expenditures.

Clearly there is a need for further and better needs assessment We should do some sampling and also use surrogate measurement to establish what the needs really are. In the 1960s and 1970s w made some serious mistakes by building too many buildings. W were not prepared to operate all of the facilities we built. Some c these facilities have had to cease operations just a few years afte they were built because of the lack of operating funds. In additio we have not closed down some facilities whose operation can n longer be justified because of political pressure to keep them oper In building facilities, whatever the source of revenue for them, i is essential to know what the full maintenance costs will be.

I do not think there has been a failure in financial mechanism or markets. In fact, I am not all that enthusiastic about creativ financing for facilities. The cutting edge hurts. In many states th only source for capital financing is the property tax. As a resul the only way to get more money into the capital budget in suc states is to cut the operating budget. The proper relationship amon federal, state, and local finances has not been adequately debate One with experience at the local level can only smile at state o ficials who admonish local officials for poor fiscal management. B and large, local governments are in much better shape than th state governments so far as financial management is concerned.

Public works departments are not the best run parts of loc government, however. Some of it has to do with the way they hav been allowed to charge the costs they incur to capital and operatin accounts. There has been a tendency to look on all funds as a troug at which to feed. There is also a need for more management tale

in public works departments. Financial departments are much stronger. Finally, there is a lack of direction and philosophy in public works, although the environmental movement has begun to provide some direction for some parts of the public facilities system.

The role of the media is very important in financing. They can make it almost impossible to carry out some worthwhile projects. It is important to the success of any effort at facilities financing that the media understand large capital issues. Otherwise their reaction is that local government is just trying to spend money and that ought not be done.

We have made poor use of resources that are available in some cases. For instance, during the time when high interest rates could be obtained on the investment of bond proceeds, many local governments did not set these funds aside for augmentation of capital funds but allowed the interest revenues to be used in the operating budget. There are often state limitations on how money can be moved around at the local level. Rules created when counties and cities were not that well run now impede good financial management.

We are also suffering from several years of budgetary dishonesty at all levels of government. There has been a consequent loss of trust in financial estimates and needs projections by government. Another area that is important is stability. Governments with stable governments and good management have been able to make better use of their resources, such as their own taxes and grant programs. They have programs and have been able to carry them out. In areas in which there is a turnover in every election, there is an inability to carry out programs. This in itself breeds lack of public trust in the capacity of government to perform.

SUMMARY

Distinctions Between New Capital Programs and Maintenance

In developing financial programs, it is important to distinguish between new capital projects and maintenance spending. It is also important to separate the different kinds of maintenance, ranging from routine operating maintenance, to major repairs, to upgrading of facilities. It is important not to use capital funds for the routine operations of a facility, but some of the things we generally regard as maintenance may be alternatives to new facilities. We must

avoid the trap of letting facilities run down to the point that they need "capital" repairs because there is no money available for ongoing maintenance.

The current rules as to what are capital and what are maintenance expenses are made not by public works engineers, managers, or bankers but by accountants following accepted government accounting practices. Their definition is not one that managers or bankers should necessarily accept. Bankers are interested in the useful life of a facility being long enough to retire the debt on it. They are not as a rule concerned that some parts of a facility or some elements of the capital program do not last for the entire life of the bond issue that finances them, so long as the part of the debt financing those aspects of the program is paid within the useful life of the part in question.

From a management perspective, there are anomalies in using the accounting definition. Equipment in a new building, for instance, is clearly a capital expense. When equipment is being replaced in an existing building, it is sometimes considered as an operating expense. Many managers prefer to err on the conservative side in making such decisions to avoid abuse of the borrowing power to finance small-scale and routine maintenance and repair or rehabilitation projects. New York City, for instance, got into its fiscal problem in part by rationalizing human capital investments, such as the salaries for vocational education, as a capital expense.

It is essential to distinguish among operating maintenance, deferred maintenance (repair and replacement), and new public facilities. Managers must make these distinctions every day. Such distinctions are critical in state, local, and national perceptions about how to handle this problem. If there is a distinction between public works and infrastructure, then public works are what you build, while infrastructure is what makes the place work.

The Advantages of an Infrastructure Bank

Most existing laws require cities to maintain facilities that are debt financed or allow the bondholders to establish such requirements. How could a federal infrastructure bank impose requirements if the bondholders will not do it?

Two separable issues are raised. With revenue bonds the interest of the bondholders is in a revenue stream adequate to repay the debt. There is no particular concern with setting a fee structure

that provides for maintenance beyond the maturity date of the bonds or for the eventual replacement or upgrading of the facility. There is no incentive for requiring a long-term management program or a fully adequate system of user fees. While most revenue bonds include covenants requiring adequate maintenance of the structure and increasingly there are requirements for capital planning and programming systems, most facilities are not financed by revenue bonds. Instead they are financed by general obligation bonds or even by current appropriations and capital grants, over which none of the financial instruments have any control. If, as a nation, we are going to tackle a capital rebuilding program, whoever is lending the money, especially if the loans are made at subsidized rates, has an immense opportunity to establish as a quid pro quo that local government make the institutional changes necessary to adequately maintain and replace facilities.

The Opportunities for and Limitations of User Fees

There is more to the user-fee concept than simply changing to whom the bill is sent. If we are to make wider use of the mechanism, there will have to be some dramatic improvements in the system. Fees collected will have to be clearly dedicated to the purposes for which they have been charged. To some extent we are trying to simulate a private market in setting user fees, and that market may give us more than we have asked for. Generally, the impetus for user fees has been to raise revenue. They have not been used as market or efficiency devices. The efficiency claims for fees as a market device relates to the way the fees are structured. When a public service monopoly charges any fee it wants and calls it a user fee, it loses its efficiency advantage.

The user fee concept is not universally applicable. It is very hard to apply it to streets, for instance. In many other areas of transportation it is difficult to come up with a politically acceptable system of allocating costs for the services that are provided. There is a question about just how far the user-fee concept can be pushed.

The important point, therefore, may not be broadening the application of user charges but deepening their use where they are appropriate so that the prices that are charged are economic prices rather than prices of political convenience. We should remember, however, that charging the economic price for services may help with efficiency problems, but it can also raise serious equity issues.

Such fees may have no correlation to the ability to pay. This is a problem to which we must be sensitive as the proportion of the local budget financed through user fees increases. There is also a growing equity problem with the use of franchises to private companies to provide services and with taxes on utilities (which are among the fastest-growing sources of new revenues), as these approaches can leave those without the ability to pay unserved.

Some other problems arise when the user fee is pushed too far. When fees for garbage collection become too high, can we stop picking up the garbage of those who cannot pay? Not if the reasons for public garbage collection are based on public health. We could also end up transferring our garbage problem from the sanitation to the parks department as people find alternative ways to dispose of refuse.

Some very sophisticated management problems can arise when services are priced at their true economic value or cost. The value to a potential user may be different than the cost of providing the service. Another problem is that people are used to certain levels of cost for some kinds of services. Rates that reflect the real cost of a utility constitute sea changes in the way people think and what they do. Rather than pay high electric power bills, they may buy wood stoves. If enough people take alternative measures to avoid these costs, the revenue stream produced by economic pricing may diminish rather than increase, upsetting the financial plan.

One final issue related to the user-fee concept is the notion that as services deteriorate in central cities, those who can pay for the services they want will just move to other places where they can purchase them. This raises the question of whether we want to or should want to maintain our cities. Perhaps there is no real choice, because there is such an enormous investment in existing cities in infrastructure alone. Moreover, if people can move to Lake Tahoe and do their work from a remote computer terminal, we had better start thinking about the kind of city Lake Tahoe will become. There are going to be aggregations of people, even as we move away from the older central cities.

The Role of Interest Rates in the Financing of Facilities

There may be an undue reaction to high interest rates. Typically, debt service constitutes only about 5-6 percent of the municipal budget. Higher rates are unlikely to raise that proportion by as

much as a single percentage point. We may have gotten caught up in the psychology of the investors' market, and we should demythologize interest rates for normal, day-to-day, general obligation bond financing, at least aside from the very large projects.

There is a lag or delay in adjustment to interest rates. There is also a tendency on the part of municipal borrowers to assume that rates will return to their historic low levels, therefore they assume that a year's deferral will have little effect. Unfortunately, there are successive deferrals based on such assumptions. With regard to perceptions, the absolute numbers can be very frightening.

Volatility is also a problem. In the 1960s, the municipal interest rate changed 10-15 times. Now it can change that many times a month. People are not used to that kind of market fluctuation for municipal bonds. In the past, a half point change in a year was considered a problem. Now one has to think about changes of half a point in a day. People are adjusting, but it will take time.

The major problem is the cost of real interest—the difference between the rate paid and the rate of inflation. Real interest is now 4-6 percent higher than the rate of inflation. In the past, the real cost of interest was zero or less. Today municipal bond interest rates are about even with long-term Treasury rates. As a result, there is no particular advantage to the investor from the tax exemption. As a result one can no longer borrow, invest in Treasury bills, and, under the arbitrage rules, end up paying no real interest. Today we are talking not just about no arbitrage, but negative arbitrage.

The Opportunity for Use of a Form of Commodity Bond

The basic problem with commodity bonds for which inflation might be offset by the rates charged for future delivery of a service or good relates to who buys them. Bond buyers are people who are adverse to risk. Commodity bonds require that the buyer make an educated guess that prices will keep up with the rate of inflation. That is too complicated a calculation for the typical municipal bond buyer. Another instrument, however, may work; a pass-through certificate would be sold to a more sophisticated customer, but that person probably will not be interested in the tax exemption.

The problem is the disappearing interest rate advantage of state and local bonds. The clearest response would be some forbearance by state and local governments in issuing all other types of bonds.

The narrowing of the spread between municipal general obligation bonds and other types of issues is largely due to the flooding of the market with other types of local issues, such as industrial revenue bonds. So far officials of these governments have declined the opportunity to declare that infrastructure is indeed a priority for debt financing and to voluntarily restrict other types of issues.

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Politics and Urban Public Facilities

Heywood T. Sanders

FACILITIES AND POLITICAL POWER: A GLANCE AT MUNICIPAL HISTORY

The development and maintenance of the urban infrastructure is largely a public function, carried out by public agencies and a variety of elected and appointed officials. The decisions and choices of these bodies necessarily reflect political interests and bargains. These choices also demonstrate a single fact—urban public facilities such as streets and sewers are rarely valuable in and of themselves. The real value of infrastructure comes in the things that it makes possible. A mayor may support the construction of a new sewer line because it is needed to serve a new plant, thereby fulfilling a political obligation to create new jobs and foster economic development. A city council member may campaign for street improvements in one district in order to even out the distribution of benefits across the city and to demonstrate attentiveness to the interest of his or her constituents. The demands of the local electoral system—to meet campaign promises, to demonstrate substantive accomplishment, to secure some symbols of action and representation—structure the public investment in infrastructure and its location. The link between political gain and the development of an urban infrastructure has been a continuing feature of American

history. Our cities have largely been shaped by the needs and desires of local officials.

Boss Tweed's Pavement Politics

The name of William Marcy "Boss" Tweed has become enshrined in the history books as an example of all that was wrong with American local government in the nineteenth century. Tweed stole vast sums of money from New York City's taxpayers, enriching both himself and his colleagues while running the city into massive debt. The most cited example of Tweed's capacity for graft is the construction of the New York County Courthouse. Originally planned to cost some $700,000, its final cost was in excess of $12 million. Its furnishings included $675,000 for carpets and shades and $7,500 worth of thermometers (Werner, 1928).

Tweed's eminent success at plundering the city's treasury does not, however, commend him to our attention. Far more important for the development of Manhattan was his ability at promoting infrastructure construction and expansion beyond the densely settled limits of lower Manhattan. Tweed engineered the legislation for and then directed a massive program of street paving in New York. Armed with legislation passed in 1869 that shifted half the cost of street improvements from abutting property owners to the city as a whole, he increased special assessment debt from $4.4 million to $12.6 million in just 2 years. This debt increase was matched by another $5.6 million in general bond issues for street improvements and $2.5 million for water supply in the same period. Boss Tweed had created a political machine for building and expanding urban infrastructure (Durand, 1898).

Construction projects had obvious merits to a politician intent on both personal gain and the distribution of favors. Contracts were awarded to favored contractors with little or no supervision but large kickbacks. Materials had to be purchased and laborers employed, and these functions provided the opportunity to reward political supporters and gain votes. The most important fact, which Tweed recognized, was that infrastructure development, particularly street paving, provided a means of sharply increasing land values and real estate development in particular parts of the city. No doubt some of the rationale for this expansion was pecuniary. Tweed's friends and supporters speculated in property on the upper East Side that was directly aided by the improvement program.

There was, however, a much larger scheme of benefits. The massive infrastructure program promised jobs to be distributed to newly arrived immigrants at the same time that it weakened the holdings of Tweed's enemies in the downtown area and the West Side. These political gains—jobs, contracts, real estate speculation as well as graft—could be managed within a modest current tax rate by passing the cost on to future taxpayers in the form of bonded debt.

The street improvement empire created by Tweed collapsed as rapidly as it had grown, a casualty of both the magnitude of its greed and the reaction of the bond markets. It illustrates the sizable political gain to be had from the expansion of basic urban systems. Building streets and widening boulevards need not be a process controlled by property owners at their convenience or superintended by local government on some rational basis. These activities provide a way to garner support and win elections, to build a political organization and guarantee campaign contributions. For Tweed the money was in the building of a courthouse and such things as printing contracts. The political and electoral power was in street paving, a lesson that may not be fully appreciated by contemporary urban politicians and professional managers.

Cleveland: A Bridge to Electoral Victory

A crisis over bridge conditions is nothing new to Cleveland. Just as the city now faces an enormous bill for repairing and reconstructing its bridge network, so it faced a similar problem in the early years of this century. The earlier crisis was one of development and growth in an era of streetcars rather than automobiles, and the dual problems of capacity and safety made a case for a new structure.

In 1900 two bridges linked Cleveland's west side residential neighborhoods with the downtown center by crossing the natural barrier of the Cuyahoga River valley. Both structures, the Superior and Central viaducts, were low-level bridges forced to open and close for river traffic and thus were the cause of regular delays for streetcar traffic. The viaducts were also overburdened by traffic, "greatly taxed to afford the proper communication between the East and West side . . . particularly noticeable at the morning and evening rush hours" (Cleveland *Plain Dealer*, November 2, 1910). These structures, particularly the Superior Viaduct, were the limiting factors to further development and growth to the west. The Superior

span also had some structural problems—flaws in the masonry piers supporting the actual roadway. The need for a new high-level span with more capacity and no interruptions by river traffic was clear to a succession of Cleveland's mayors and councils and was pressed by west side business and commercial interests. The funding for a new bridge was dependent, however, on voter approval of new bonds, and the voters proved rather less impressed by the "need." Requirements imposed by state law for a minimum two-thirds majority approval at the polls also hampered the translation of need into action.

The city's first popular vote on the bridge bond issue was held in 1905 and was successful. It was nonetheless declared invalid due to a technicality in advertising the referendum. A second attempt in 1906 failed, followed by two further failures at the polls in 1908 and 1909. Local politicians read the mood of the voters as being antitax and antidebt. As the Cleveland *Plain Dealer* commented in a 1910 editorial (May 11, 1910): "It is clear that a two-thirds affirmative vote for city bridge bonds could not be secured either now or in any circumstances likely to soon develop. . . .The important consideration is that the bridge be built right and soon."

The popular failure of the bridge issue was clearly rooted in some perception of voter self-interest. Contemporary political leaders noted the unwillingness of the taxpayers to support any further debt for public improvements, be they viaducts or a new city hall. This reluctance was particularly notable in the case of east side voters who stood to bear the costs of the new structure while receiving no apparent benefit.

Bridge development was clearly stalemated by the mood of the voters, and the situation demanded some political leadership or initiative. That leadership eventually came from a single elected official, with a constituency that was larger than just the city and who needed to create a new political image. W. F. Eirick, a Republican, was first elected to the Cuyahoga County Commission in 1903 but lost his seat in a Democratic sweep in 1906. Two years later he ran again, this time campaigning on a platform backing *county* construction of a new west side bridge. The county lacked the formal authority to build such a structure within the city, but Eirick argued that the legal restrictions could be overturned and the viaduct built by the county government. Eirick's success in winning back his commission seat in 1908 led to the filing of a test suit on the bridge

construction. Both Eirick and Cleveland's elected officials recognized that a quirk in the state law required only a simple majority for bond approval in contrast to the two-thirds minimum for a city issue. With judicial acquiescence in 1910, the county commission moved quickly to place the bridge issue before the voters once again. The county proposal managed a substantial popular majority in November 1910, with voters outside the city of Cleveland combining with loyal Republican voters in the city in support. Design and construction for the new Superior Viaduct commenced quickly, and the new structure was opened to streetcar traffic in late 1917.

The impact of the high-level span was substantial. By doubling the number of streetcar tracks and eliminating delays, it increased the accessibility of the west side and spurred new development there. In the suburb of Lakewood immediately adjacent to Cleveland, one history notes (Rose, 1950:1081):

> A second real-estate boom came with the opening of the Detroit-Superior High Level Bridge over the Cuyahoga River in 1917, and prices of lakefront property soared as high as $15,000 an acre.

Eirick's personal support of the bridge development created an entirely new provider of public facilities for Cleveland—the county government. It also provided substantial political rewards for Eirick. The bridge issue served to differentiate Eirick from the mass of Republican county candidates and to provide an unusual level of public visibility. The result was that the candidate who was defeated in 1906 went on to lead the Republican ticket in 1908 and 1910, outpolling the well-known state and national candidates. His endorsement of the county initiative in building the viaduct also brought Eirick the support and endorsement of the influential Municipal Association in the 1910 election.

In a political environment in which party loyalty superseded both issues and personalities in importance, W. F. Eirick was able to use an infrastructure need both to gain new electoral support and to create a positive image with the voters of Cleveland and Cuyahoga County.

Public Works as Political Strategy

Tweed in New York City and Eirick in Cleveland demonstrate the extent to which the development of urban public facilities has

been dependent on political decisions made for political purposes. Tweed's success in plundering the city treasury should not divert us from an appreciation of his use of street paving. Contracts for the county courthouse and a variety of city purchases sufficed to make Tweed a wealthy man and to enrich his colleagues. The street paving program was a much less substantial source of corruption. Its principal advantage lay in the employment, through private contractors, of hundreds of laborers drawn from the city's immigrant population. Corruption and personal gain were necessary elements in forming political alliances in a notoriously disorganized environment, but the jobs from the paving program were a means of gaining and controlling voter loyalties. The need to get elected and reelected spurred Tweed's infrastructure program.

Eirick's efforts to promote the building of a new Superior Viaduct suggest nothing of the outright corruption of the Tweed endeavors, yet they were motivated by the same forces. The bridge issue differentiated Eirick from a mass of Republican politicians and brought him a much wider base of electoral support and the reelection he sought. Political need, in short, pressed both Tweed and Eirick to adopt public facility development as a strategy for electoral success.

American cities today are manifestly better governed and far less corrupt than they were in Tweed's day. City managers are more commonly municipal leaders than party bosses; the national political parties are largely absent from local politics; and urban administration has been placed on a more rational and efficient basis. The political potential of infrastructure development nonetheless persists. Bridges, streets, and water and sewer lines are built not only because they carry some unique intrinsic value to some city decision makers, but also because of the larger benefits and rewards they promise. The political value of infrastructure is not confined to elected officials and the contest for popular support. Public agencies and their managers also act in a political fashion, seeking to build outside support, enhance their professional image, and enlarge their programs and budgets. Infrastructure programs and projects thus serve political purposes even as they are allocated and evaluated by urban professionals—as a means of rewarding an important or supportive department head, sustaining city employment and employee loyalty, and absorbing and alleviating fiscal pressures and budgetary crises.

TODAY'S INFRASTRUCTURE CRISIS AND THE POLITICS OF URBAN DEVELOPMENT

The Deferral of Capital Improvements

Any number of recent analyses of urban public facilities have suggested the forthcoming collapse of streets and bridges, and the wearing out of the urban infrastructure. While the true extent of these problems is clearly open to question, their genesis in a number of specific communities is clear. Large portions of the current bill for infrastructure rebuilding have been around for a lengthy period of time. The infrastructure crisis is not simply one of recent vintage, reflecting some underspending in the last 4 or 5 years; rather, the needs for physical improvement of many cities have been known and deferred over an extended period. In Cleveland, for example, a 1979 study noted a need for more than $150 million in repairs to the city's network, with a substantial number of structures requiring immediate replacement or major rehabilitation (Humphrey et al., 1979). While the total magnitude of this problem is impressive, it constitutes nothing new. A report by Cleveland's city engineer in 1968 requested the participation of state and county authorities to solve Cleveland's bridge problems as well as at least $20 million in city bond authority for the 1968-1978 period for replacement of the worst bridges. As that report noted, "There is virtually no end to bridge replacement needs and the City of Cleveland does not have the dollar resources to go it alone" (Wolfs, 1968:1). The magnitude of the problem had only grown in the subsequent 3 years, for the 1971 bridge inspection report argued that "an amount of $55,000,000 in bonds or supporting state, county and Federal money is necessary immediately to keep the bridges in the City of Cleveland satisfactory" (Stamps, 1971).

The bridges that required rehabilitation or replacement in 1979 were much the same structures that had concerned Cleveland's engineers in 1968, 1971, and the intervening years. Their needs simply grew more serious and more costly with the passage of time. Cleveland faced a bridge crisis in 1979 and 1980 not because it was unable to identify a problem much earlier; it faced that problem because clear needs were deferred.

The persistent character of infrastructure needs is also suggested by New York City's situation. The condition of the city's streets has

been a standing joke for years. If the resurfacing cycle implied
the volume of activity in the late 1970s (following New York's fisc
crisis) amounted to 200 years, it was but a moderate change. Pri
to the loss of capital funds resulting from the crisis, the resurfaci
cycle had averaged 120 years. Even the 120-year cycle is probab
an overestimate of the actual performance—much of the city's effo
was centered on the construction of new street pavement or t
reconstruction of roads linked to major new developments.

Other elements of New York's infrastructure needs also show t
same sort of historical continuity. The city's 1983 capital budg
allocates $120 million to the further construction of a third wat
supply tunnel, on which construction had begun in 1970. The ne
for the tunnel has been strongly argued recently: "We need to ha
this third water tunnel available so that we can fix one of the oth
two that are I think respectively something like 74 and 77 yea
old" (Koch, 1982:9). This same sort of need was the rationale f
proposing the tunnel in 1960 and 1966. Indeed, the need for a
additional water tunnel has existed ever since the completion
the second tunnel in 1936. This sort of delay, it might be note
would appear to be New York City's historical norm. The secor
water tunnel was formally proposed in 1921, approved by the Boa
of Estimate in 1927, but not completed until 1936. Its completic
eventually required the financial aid of the federal governme
under the Public Works Administration.

These examples of problem persistence do not canvass the enti
array of public facility needs, but they do suggest that the curre
situation has not developed overnight. The problems of street
bridges, and water and sewer systems have existed, been reco
nized, and been documented for an extended period. The issue h
been a matter of translating this recognition into public action.

Financing Public Works: The Political Environment Since 19

The persistence of infrastructure needs over time in such con
munities as New York and Cleveland should also raise questio
about the linkage between fiscal health and the condition of publ
facilities. The decay of these structures and systems cannot be a
tributed simply to a decline in urban capital spending followir
such crisis events as the collapse of capital spending in New Yo
and Cleveland, the austerity faced by such older cities as Detro
and Boston, and the broad impact of Proposition 13 on Californi

communities. While these events did undermine the abilities of cities to meet capital improvement needs, many of these same needs had gone unmet in the preceding few years. The period of the late 1960s and early 1970s, when Cleveland documented its bridge replacement needs, was a boom time for capital spending.

Capital expenditures in Cleveland during the 1950s and 1960s had been kept to a minimum, reflecting both the reluctance of the electorate to endorse expensive bond proposals (more than half the proposals on the ballot from 1956 through 1966 were voted down) and the unwillingness of political leaders to increase taxes in a city of homeowners. Total capital spending, including items backed by revenue bond funding, was kept to $30.8 million in 1964 and $30.4 million 2 years later. The expenditure growth at the beginning of the 1970s was equally modest. Spending came to $34.8 million in 1970. The great increases followed shortly thereafter, with spending at $42.4 million in 1974, $131.1 million in 1976, and $97 million in 1977.

A part of Cleveland's capital spending boom was due to self-financing activities, such as the water system and airport expansion. But much of it was also due to the initiation of a number of development-oriented projects in the downtown area. The city constructed a new central police station as part of a countywide courts complex, with a bill for Cleveland of $60 million. It also managed to fund the widening of a downtown street and the installation of a median strip at a cost of $1 million in 1977.

Cleveland had the financial resources to address any number of its needs in the 1970s. Indeed, the bond fund for city bridge improvements and rehabilitation showed a substantial unexpended balance for most of this period. When the first major report on bridge condition was submitted in 1968, there was almost $4 million in available funds. As late as 1974, city books included about $3 million in unexpended bridge monies that could have been committed to replacement.

Cleveland's capital investment increases were by no means unique. Boston's capital program grew from $31.5 million in 1969 to $109 million in 1976, the peak spending year for the decade. This capital spending funded a great many projects and supported a substantial volume of private investment and development, particularly in the central business district. What it did not support, in general, was expansion of more traditional capital programs. As the aggregate capital program expanded, expenditures for street reconstruction

remained unchanged—$3.2 million in 1970 and $3.24 million in 1976—even as inflation increased the cost of street work. Stability in actual dollars or even decline was also the case in such areas as bridge rehabilitation and sewer improvement. The expansion of capital spending in Boston provided the opportunity for greater expenditures and greater response to infrastructure needs—but that response did not take place.

New York City provides a final case of the capital investment environment since the 1960s. The city's capital program through the early 1960s had been a modest one, designed to respond to new growth on the outlying areas of Queens and Staten Island while completing the city's arterial highway and expressway network. John Lindsay's assumption of the mayor's office had marked a sharp change in both the size and character of the capital construction. New York's capital construction contract awards amounted to $204 million in 1966; by 1970 they reached a total of $723 million, then grew to $1.1 billion in 1973.

Lindsay and his staff had the opportunity to substantially expand the city's capital program—"people were begging for our bonds" (interview with David Grossman, 1982). That opportunity was exercised in a number of functional areas. Spending for new school buildings increased sharply over the previous levels, reaching a peak of over $200 million in 1972. There were similar sharp increases in the general building program, including new fire station and police precinct houses as well as for parks and recreation facilities. In more traditional infrastructure areas, the rate of new spending grew more modestly. Street and highway project contracts increased from $12 million in 1966 to $22 million in 1970, with a peak figure of $36 million in 1973. Even these figures can be misleading, for much of the new street investment supported new development, such as the Hunt's Point Market and the rehabilitation of Yankee Stadium. In 1969, for example, $4 million of the city's $21.5 million highway program was devoted to the construction of new streets in the Co-Op City housing complex in the Bronx. The funds were available to resurface New York City's streets at a regular and substantial pace, to replace water and sewer lines where necessary, and to meet other needs of growth.[1]

[1] New York City's largest single infrastructure project, the Third Water Tunnel, was partly justified by the need to accommodate the city's population growth. The tunnel was designed to serve an eventual population of 9.4 million by 2010. The city's 1980 population was slightly more than 7 million, a 10 percent drop from the 1970 figure.

Public Facilities and the Politics of Urban Growth

While some cities have struggled to finance and maintain basic public facilities, others have managed massive investments in expansion and addition. Cities in the Sunbelt have made infrastructure a central political priority because of its critical tie to urban growth and development. For example, Phoenix, Houston, Albuquerque, and San Jose have all managed major public spending for infrastructure over the last two decades. They have managed that task as part of the politics of growth, because growth was politically salable and vital in each of these communities. In some cases, local government simply became a vehicle for delivering the new streets, sewers, and water systems needed for new residential development and for representing the interests of bankers, realtors, and property owners. Capital spending in Phoenix increased from $20 million in 1967 to more than $70 million in 1978. These funds both supported new development and replaced the inadequate public facilities of earlier growth periods.

The construction of growth-related urban infrastructure over the last three decades has often involved a combination of local government, state and federal government, and private financing. Federal grant support for water and sewer systems and for interstate highways and urban streets has reduced the burden on local treasuries. The demands of urban growth have nonetheless demanded a single-minded emphasis on infrastructure construction in local capital programs. The development of arterial streets and storm drainage projects for fringe areas dominated San Antonio's capital spending and bond programs during the 1960s and early 1970s. Albuquerque's bond programs, which require voter approval, also illustrate the political priority of infrastructure in some contexts. In 1966 Albuquerque's voters passed a $22 million package of capital projects, 89 percent of which went to streets, drainage, and water and sewer systems. The city faced a series of competing demands for public facilities throughout the 1960s and 1970s, as citizens requested greater priority for parks, recreation facilities, and libraries. Yet by 1974 the city was still devoting 81 percent of its capital effort to infrastructure projects.

This pattern of high public investment for basic infrastructure in growing communities, even where these investments require voter approval at the polls, has been repeated in numerous localities. San Jose managed to spend more than $3 million for street

construction in 1965, the same year it allocated a grant total of $148,000 for parks, recreation, and city libraries. There is clearly some political mechanism operating in these growing cities that supports infrastructure spending as a high proportion of local capital investment—a political mechanism that fails to support this type of spending in other places.

It is important to note that the political mechanism is not simply "cheap money" or readily available local revenues. Albuquerque operates under a highly restrictive state law on its debt and capital spending. San Jose managed substantial spending for streets from new revenue sources after its voters turned down two successive bond proposals. The fiscal bind on many growing cities is often similar to that faced by older urban centers. The difference is that the Albuquerques and Phoenixes have devoted their available capital resources almost exclusively to infrastructure development for new areas and new community residents.

The political model that Boss Tweed established in New York in the middle of the nineteenth century bears some striking similarities to the politics of infrastructure development and growth in the last two decades. Growth-related investment generates political values that can be both general, covering the entire local community, and quite specific. The communitywide products were laid out clearly by George Starbird, a former mayor of San Jose (Starbird, 1972:3):

> It was not self-aggrandizement of the administration as the critics like to shout. It was the spreading load of the treatment plant and sewer grid, the attraction of a growing income from sales tax and the compulsion to keep the city limits free and elastic.

Aside from concerns over community size and importance, growth meant that government could be financed more easily, with more people sharing the cost of existing facilities. It also meant new and greater revenue sources for the city. In one community, surplus revenues from water and sewer charges were funneled back into the general fund to relieve chronic pressure on traditional services. The growth orientation of the capital program, in turn, provided a means of expanding the urban population and the consequent water and sewer revenues. Growth did not just imply some larger and more impressive city; it provided real short-term returns to a city manager with a persistent fiscal problem.

There were also very specific benefits to growth and capital in-

vestment, benefits gained by landowners, subdividers, and builders. The extension of sewer lines and the widening of a country road meant substantial profits as orchards and truck farms were turned into residential subdivisions and shopping centers. In Tweed's day, this sort of opportunity implied making a political choice, providing public goods for your friends and supporters, and denying them to opponents. Such machinations have been far less common recently. Spend enough capital dollars, provide for enough new development in outlying areas, and a city manager could benefit a whole range of groups and individuals in the development business without being forced to choose among them. With a sufficiently large capital program and a commitment to growth, some cities have managed years of local development and expansion with little or no political conflict.

There are other opportunities that growth creates for financial advantage and gain. Massive building programs require the services of consulting engineers, contractors, and construction labor, and each of these groups stands to gain from a high level of public infrastructure investment. In some communities, they became not only the principal beneficiaries of development, but also its principal supporters. In San Jose, that support for development and endorsement of the needed bond proposals was loosely organized as the "Book (or Buck) of the Month Club." In the words of former mayor George Starbird (1972:5):

> Of course, we were selling these bond programs to the voters too at the same time. About here the Buck of the Month Club, who had formed to back the administration in their bond elections were a power that attracted interest throughout municipal circles. This loose combine, called Buck of the Month, was composed of a number of contractors, developers, businessmen with a smattering of less well-heeled public officials. Their ability to put up seed money that attracted other money to advertise campaigns gave us the push to get ahead.

The business firms and individuals with the most to gain from a large program of public construction proved to be the best supporters of the bond issues used to finance that construction. They provided an attentive constituency that encouraged public facility construction, promoted it among city officials, and effectively guaranteed its support at the polls.

While the best supporters of infrastructure construction were the paving contractors and materials suppliers who had an immediate

financial stake in public building, there was no need to pick and choose among them, to reward some favored firms at the expense of others. A major development program could provide work and benefits for a broad array of contractors and engineers, with little pressure of the sort generated by an occasional city contract and the stiff competition in bidding to get it.

Urban growth and expansion provide a range of political and economic benefits that support building and investing in streets and sewer lines. Those benefits do not involve wholesale public ceremonies—ribbon cuttings by the mayor at each new segment of trunk sewer lines or paved arterial. Television and newspaper coverage rarely accord much space to these "routine" developments. Yet their value to mayors and public officials is immense. Unlike proclamations about a local war on crime or the hiring of hundreds of new police officers, public works cannot be translated into an issue of mass appeal to a city electorate. They nonetheless offer the opportunity for political advantage and gain.

STANDARDS, NEEDS, AND PUBLIC ACTION

Formal standards provide perhaps the most useful, rational approach to justifying infrastructure needs for replacement and rehabilitation. Street pavement, bridges, sewer lines, and public facilities of all sorts gradually deteriorate with age. With some rough estimate of that useful life, it is simple to estimate how much spending and effort—be it street resurfacing or sewer replacement—should be carried out in a given year and maintained on a regular basis.

The great appeal of standards is that they are rational. A particular standard for street resurfacing calls for a given volume of activity each year, without the intervention of some crisis, neighborhood demand, or political bargain. The standard also operates independently of the choice of streets (or other facility) to be repaired or improved. By regularly resurfacing a tenth (or a twentieth) of the local pavement, all streets should be taken care of over their lifetime.

Engineering Standards

Most cities appear to have promulgated and accepted standards as a means of providing for the rehabilitation of their infrastructure.

There is some variation—one city may have accepted a 10-year standard for streets, while a 15- or 20-year standard may be acceptable in another community. Standards of this sort are almost universally used as a basis for allocating public resources.

Boston's highway engineers generally accepted a standard of 20 years for resurfacing in the early 1960s. By 1980 they were still talking in terms of a 25-year replacement cycle as a reasonable figure. This broad standard for street work was generally accepted within the city. The city's major statement of capital needs prepared in 1963, *Renewing Boston's Municipal Facilities*, both formally proclaimed the standard and acknowledged the city's previous failure to meet it (Boston Redevelopment Authority, 1963:39):

> To replace road surface once every twenty years on a regular schedule will require thirty-seven miles of reconstruction annually. Based on current average costs of eighty thousand dollars per mile, this means three million two hundred thousand dollars every year. In the nineteen hundred and fifties annual spending for public ways totalled about two million three hundred thousand dollars a year. Shortage of funds and shortage of manpower led to a backlog of reconstruction projects.

Boston thus accepted not only the street standard and the financial burden needed to meet it, but also the requirement for an increased level of spending to remedy the $14 million backlog of reconstruction projects that existed in 1963.

Local standards are not immutable. They have a way of changing as larger forces impinge on the city's ability to improve its street network. Oakland's maintenance engineers thought a 10-year resurfacing cycle was appropriate in the 1950s, at a time when the city could afford a substantial street program. By 1980 a 25- or 30-year standard seemed more plausible and acceptable outside the public works department. The city's fiscal circumstances had rendered the 10-year standard implausible by the early 1960s.

The standards established by both Boston and Oakland were generally accepted as the best estimate of street needs, and they were used to justify regular annual funding requests. But they didn't work.

Boston made a dent in some of its reconstruction backlog in the early 1960s, but it gradually fell behind both that need and the formal standard proclaimed in 1963. By the early 1970s it was spending about $3 million a year on reconstruction projects: less than what was called for under the 20-year standard in 1963, despite

a cut of more than half in the purchasing power of those expenditures.

Oakland's situation was no better. The 10-year standard was effectively dead by the early 1960s: limits on funding had created roughly a 40-year resurfacing cycle. As the city's fiscal needs continued to limit public works activities throughout the 1970s, the resurfacing program suffered. The 1980 funding apparently supported a roughly 100-year cycle, and, in the absence of additional federal aid funds, the street activity slipped even further.

Cincinnati provides an interesting contrast to the ineffectiveness of standards in Oakland and Boston. It has received substantial publicity for its recognition of capital needs (Gorham, 1979:xi): ". . . one older city that has paid attention to the condition of its physical plant." Cincinnati's capital improvement plans dating back to the late 1940s have emphasized the importance of city streets (Cincinnati City Planning Commission, 1949:13): "Keeping them in good condition must not be overlooked." At that time the city accepted the need for a 20-year resurfacing cycle, requiring annual expenditures of some $400,000, and the city manager in 1956 implored the city council to maintain that level of funding. There was some slippage in the standard over the years. The 1976 budget request from the highway maintenance staff argued that "mechanical resurfacing [is] a necessary requirement every 15 years to protect the street and extend its useful life."

Cincinnati's street standard has been a bit more ambitious than those in Oakland or Boston, in terms of the volume of annual funding and work. It has historically been no more effective than those cities in actually getting the required funds from a perpetually strapped city treasury. The city manager's suggested level of financing would have paid for 40 miles of new pavement in 1956. By 1957 the city was actually resurfacing about 15 miles, and that figure dropped further to 7 miles in 1959. The ultimate cost of that reduction was clearly stated in the Highway Maintenance Department's annual report (Cincinnati Highway Maintenance Division, 1959:7):

> Only half those streets in immediate need of rehabilitation were resurfaced. The projected continuance of this reduction in future Capital Improvement Programs will result in a slow but continual deterioration of the city street system unless funds are provided from another source.

These arguments, which combined elements of the formal standard

with a justification based on "immediate need," proved unavailing. The level of resurfacing supported by the capital program remained at approximately the 1959 level (about one-sixth of the activity suggested by the standard) until the middle of the 1970s.

Political Standards

A formal standard proved no more successful in supporting the street program in Cincinnati than in Oakland, Boston, or a number of other cities. While the standards may have been based on reasonable engineering criteria, reflecting local experience with the effects of winter freezes and truck traffic, they did not (and do not) reflect reasonable political criteria. To a mayor pressed by demands for city improvements and the need for reelection, resurfacing lacks the visibility and mass appeal of other projects and issues. This situation is magnified when there is no linkage between the size of the resurfacing program and the actual streets to be improved. If public works personnel choose streets based on criteria of pavement condition or citizen complaints (as many do), the mayor is likely to find little political gain or reward from a vigorous resurfacing program.

A standard's lack of political appeal is likely to pose similar problems for an appointed city manager. Street resurfacing, as with most other public works activities justified by a standard, carries no effective short-term costs and few benefits. If the standard is violated, the streets will not fall apart nor swallow cars whole. If the cost is steady but slow deterioration of pavement, it will probably take at least a few years before any major problem of riding quality exists. Street maintenance can be deferred into the future with little likelihood of massive public outcry or pressure. At the same time, even a vigorous resurfacing program must omit some needy streets, leaving some neighborhoods or individuals dissatisfied. Deferring resurfacing is a common response of a manager to competing budgetary demands, and that response is often echoed by other participants in the budgeting process. In a number of cities, public works officials have themselves reduced resurfacing funds in favor of new construction projects, believing them to be both more important and more salable to the community. Elected officials also have an opportunity to veto spending on rehabilitation and replacement projects in favor of their pet interests—downtown development, neighborhood recreation centers, or new police cars.

One of the problems in applying a formal standard to public facility renovation decisions is that the standard suggests nothing of the specific problems or failures that should generate public action. The need for a load limit on a bridge that serves an industrial park, the overloading of a combined sewer in a residential neighborhood, and the deterioration of a concrete pedestrian walkway are examples of specific needs that affect the decision-making process. Needs provide far more substantive support for funding because they are tangible items, with clear costs and benefits. Budget requests based on substantive need have traditionally received somewhat more favorable response from mayors and managers than those based purely on standards. This political reality has clearly been accepted by an increasing number of communities recently, as such devices as street inventory systems, which document the actual location and character of poor pavements, are substituted for simpler 15- or 20-year resurfacing standards.

Needs

Needs represent infrastructure problems that have been examined, evaluated, and related to a particular price tag. They still have to be processed by political systems that must trade off competing programs and interests. Cincinnati provides one case of that processing following the identification of a need.

With a hilly topography, a network of streams and creeks within the city limits, and a combined sewer system, Cincinnati has always had problems with storm drainage. Many of them were simply avoided when the original sewers were installed, because of the added cost, but they did not disappear. The city's sewer engineers identified in 1965 some 300 projects designed to alleviate property damage and flooding, at a total cost of $48 million. Faced with a substantial bill for drainage improvements and other competing concerns, the program was simply ignored. Some in Cincinnati may have hoped that these problems could be addressed by someone else, for the city transferred its sewer system to a countywide public authority in 1968. That arrangement nonetheless left the city with the responsibility for storm drainage improvements beyond the existing combined sewer system.

Storm drainage projects were regularly at the bottom of the priority list of capital improvement projects during the 1970s, despite the complaints of citizens and the requests of city engineers. The

average spending on storm sewer projects from 1970 through 1975 was about $40,000 per year, just enough to eliminate one or two small problem areas. The pace of complaints was regularly increasing during the latter part of the 1970s, as the city involved neighborhood organizations in the budget process and discovered the character of popular concern. The result was a full-scale study of storm drainage needs conducted in 1979, which indicated a total cost of $53 million for necessary projects as well as a backlog of simple maintenance problems.

Cincinnati has begun to commit more capital funds to drainage projects (roughly $500,000-700,000 per year since 1980), but it is unlikely that the city will ever be able to afford the full cost of meeting its storm drainage needs. The need for these sorts of infrastructure improvements has been clearly documented and accepted over the years. It has simply been too difficult and too expensive to meet them in any comprehensive fashion. The result has been (and continues to be) a patchwork response to crises and to those neighborhoods for which available federal funds can support a larger program. Despite the documentation of need, the public works staff has tended to restrain its requests for funds, and those requests have in turn been cut at higher levels. There is, in short, almost no prospect of a comprehensive response to Cincinnati's drainage needs within the city's existing fiscal system.

Cincinnati is not the only large city with persistent problems of flooding and inadequate drainage, leading to sewage in basements and property damage. Cleveland has historically also faced such infrastructure problems. A series of reports completed in 1973 documented the magnitude of the city's small sewer capacity problems—a need for $257 million in improvements. Cleveland has also faced a situation as bad as (and since its 1978 default, far worse than) that of Cincinnati. Yet Cleveland's expenditures on local sewer and storm drainage projects during the 1970-1980 period amounted to almost $45 million, financed from both other general obligation bonds and federal aid. Despite the city's reputation for governmental and political difficulties, Cleveland has succeeded in meeting a substantial portion of the identified needs for local sewer improvements.

The contrast between Cleveland and Cincinnati reflects far more than the ability or willingness of decision makers to address public facility needs. It is the result of differences in the formal structure of popular representation, differences in the competition for local

political office, and differences in the responsiveness of public officials to the particular needs of small neighborhood areas.

Rational justifications of infrastructure rebuilding appear to face serious problems in generating public action. Needs and standards operate in a vacuum, due in part to their lack of specific content and to the size of the fiscal demands they impose. Where there is a specific demand and need for infrastructure renewal—a single storm sewer project, street resurfacing around a new office building project—that need can be met easily without accepting a much larger request for storm sewer replacement or street resurfacing. This phenomenon occurs regularly in cities of all types, with a variety of forms of government. City managers in general appear no less entranced by broad statements of need than directly elected mayors.

Filling Potholes and Budget Gaps

This discussion of specific city cases has thus far suggested that infrastructure rehabilitation and replacement is systematically undervalued and underfinanced by urban governments faced with competing demands. There are, however, clear cases of substantial local government support for these same activities. Cincinnati's efforts to preserve and enhance its existing capital stock are among the best known in the nation, and it provides a useful case of the forces that act to expand infrastructure rebuilding.

Street resurfacing in Cincinnati during the early 1970s was not a particularly salient concern of the city manager, the elected council, or even the leadership of the public works department. There were often some capital improvement funds available for the annual resurfacing effort by city personnel, but they depended on the city's fiscal condition and rarely met the requirements of a standard or the budget request by the highway maintenance staff. For example, when federal revenue sharing began in 1972 it provided a bonus in city revenue and an extra $200,000 for the resurfacing program.

The relative poverty of the resurfacing program began to change in 1975 with the approval of a $300,000 program of major street repairs. This increase was followed by another, sharper one in 1976 and 1977, bringing the capital funding to about $900,000 per year. The initiative for tripling the resurfacing program in a period of 2 years did not come from the public works department. It originated with the manager's office and the city's budget staff. Cincinnati

was, in the mid-1970s, operating-fund-poor and capital-fund-rich. Budget officials viewed the streets program as a way of saving money by transferring costs to the capital program. In a sense Cincinnati substituted resurfacing for traditional pothole-filling and used capital funds to pay the salaries of laborers and truck drivers in the highway maintenance program. The decision did not reflect any particular concern over street conditions or the value of local public facilities. It was a simple way of easing an immediate budget problem.

Had the city's fiscal circumstances improved and no other factors intervened, it is quite likely that the resurfacing program would have returned to its previous modest existence. Instead Cincinnati was hit with two severe winters and a crisis in street conditions. Engineers estimated a need for more than $13 million in repair funds in early 1977. While that need was not met, the city did increase its previous resurfacing effort by 2.5. The achievement of that increase was largely the result of the federal government, through funds under the Local Public Works Act. That funding was a one-shot deal, and it still left substantial unfilled street needs.

Cincinnati began the final phase of its infrastructure turnaround in 1978. In that year the city began a major commitment to resurfacing, with a $2 million capital program that has now reached an annual level of $4 million. But just as earlier increases reflected the larger needs of the city rather than any particular concern with streets, so the last shift reflected organizational concerns. Until 1979 the resurfacing program had been carried out by city personnel directly. After 1979 the city contracted for resurfacing, with the engineering, design, and contract preparation performed by the city's engineers—a different part of the public works bureaucracy from the maintenance staff. The change was far from accidental. The engineering staff was the heart of the public works department and closest to the public works director. It had always handled the engineering for the regional expressway program and a host of other building projects, and its payroll was dependent on the size of those construction projects. By the late 1970s the expressway program was effectively completed, the city's building program at a halt, and the engineering staff faced with the prospect of no work and sharp personnel reductions. The simple solution was for the engineering division to take on a new responsibility to replace those it had lost, which could continue to support its payroll and employ a group of civil engineers. Resurfacing was that new responsibility.

Street resurfacing did not boom in Cincinnati because of any great revelation over the role of streets in urban life and government. The toll of winter storms had excited public concern and required a response. The needs of city bureaucracy supported a change in the character of that response and continuation of the resurfacing program. The city spends money to resurface streets not because the streets themselves are particularly important or valuable, but because of the side benefits produced by this particular capital program.

"GOODIES"

The real political value of urban infrastructure improvements is to be found in their specifics—projects that benefit and are visible to a specific ward, neighborhood, or city block. Specific projects provide a form of political currency, which can be exchanged and doled out, employed to reward and punish, to build political coalitions and win votes. The political value of rebuilding a sewer or resurfacing a street thus reflects some popular interest in this sort of project and the ability of an elected official to decide who gets what.

Local elections may provide the surest incentive for undertaking public facility improvements. Specific projects provide a means of winning votes and political success, and they are often central elements in a mayor's electoral strategies. As one study of mayoral politics in Philadelphia discovered (Howitt, 1976:159): " 'Neighborhood collective goods'—for example, new branch libraries or fire stations, street paving, augmented police patrols—are . . . widely perceived as a means of soliciting votes (an inducement) or acknowledging electoral support (a reward)." Some streets in Philadelphia may get repaved outside the political process, simply because their condition is so bad. But others are part of the political reward system controlled by the mayor. If Philadelphia and other cities simply divided their resurfacing program in half, with the mayor controlling a portion of the dollars and the city's street maintenance staff the balance, this political style of project allocation would be of little interest. There is, however, substantial evidence that the process of doling out goodies to neighborhoods and wards actually increases the total spending on infrastructure rebuilding efforts. If the city faces some serious fiscal constraints, the goodies

may be produced just before or just after election time—yet they are still produced.

The political value of resurfacing or sewer improvements acts to cushion these activities against both fiscal downturns and competing demands for such things as police protection and downtown redevelopment. The construction of a shopping mall or an office building in the central business district may win friends among the business community and further local economic development goals, but it does not translate into votes and electoral success the way specific neighborhood-oriented projects can.

Mayors and city council members can use capital projects as a way of winning elections. These same sorts of activities also provide an invaluable role in the day-to-day business of running city hall. The exchange of specific projects is a way to obtain the support of a council member for an important citywide project or the acceptance by a neighborhood of some less pleasant public improvement, such as a refuse transfer station. As long as council members and neighborhood organizations value such things as resurfaced streets and the alleviation of drainage problems, there is a rationale for trading benefits for other sorts of support. Infrastructure needs are addressed not solely because of some formal engineering study or abstract replacement standard, but also because they provide political advantage.

Cleveland presents perhaps the clearest example of the relationship between political gain and infrastructure investment. A large share of the city's capital spending has traditionally been oriented to specific neighborhood improvements that could win votes at the polls or in the city council. The political benefit of these small-scale improvements has been partially a result of political structure. The former city planning director has noted (Cogger and Krumholz, 1975:4):

> Cleveland's City Council is composed of thirty-three persons elected by ward for two-year terms. Since certain capital improvements have a high degree of public visibility, councilpersons have a considerable stake in the allocation of the city's capital resources. They are willing to trade votes on a wide range of issues for the construction of a recreation center or fire station, the rehabilitation of a playground or health center, the paving of several streets or the provision of sewer improvements in their wards.

The combination of a ward-based council and brief terms means

that Cleveland's council members have to meet the immediate ne of their wards and deal with pressing public complaints. Failure remedy a persistent basement flooding problem could mean def at the polls, and council members have regularly lost reelect bids because of such issues.

The magnitude of Cleveland's sewer problems and their existe across the entire city means that they can also be used to advant by mayoral candidates. Cleveland spent less than $900,000 for sm sewer projects in 1977, the last year of the Perk administrati The following year, under Dennis Kucinich, the city began w on almost $17 million in sewer improvements. Kucinich had de responded to popular complaints in a number of neighborhoods a promised precisely the sort of capital program that could appea local interest and win votes. The types of projects that prov political gain generally involve visible local benefit and public c cern. In the case of the sewer projects, the political system co translate a need into action because of popular concern.

Sewer improvements brought rewards at election time. Ot public projects aided both in elections and in gaining other mayo goals. Cleveland has always had a substantial and well-funded str resurfacing program. During the 1960s the city regularly resurfa between 20 and 25 miles of local streets, in addition to other str improvement and reconstruction projects. Street resurfacing also been one of the best political goodies available to the may City council members have traditionally valued new pavement a visible index of their efforts on behalf of their constituents, a mayors have been willing to trade extra streets for political supp As mayors have sought to do more to accomplish their own p grammatic goals, they have also increased the total resurfac program, providing more and more goodies to spread to their frie Thus the overall resurfacing effort more than doubled in the ea 1970s.

The true value of street work in Cleveland was proven follow the city's default. Despite an almost nonexistent capital impro ment program, Cleveland managed to find money to resurface streets. Indeed, when the city sought public approval of an inco tax increase in 1981, a portion of the capital funds was dedica specifically to the local street program. Politics works quite ef tively in Cleveland to guarantee the rebuilding and improvem of local physical infrastructure. It works because the local elec officials who decide how much and where have a standing inte

in specific improvements in their wards and in resolving the problems of their constituents.

Cleveland's political approach to infrastructure renewal has not been an unalloyed success. As noted earlier, the city has faced a serious problem of bridge deterioration, and some of its larger public facilities, such as the water system, have been the victims of major underinvestment over the years. To some extent, these are the natural failings of a system that concentrated on local improvements at the expense of broader concerns. The refrain that "bridges don't vote" has often been employed to explain the orientation of the political system. While this explanation does contain a kernel of truth, it is far from satisfactory. Cleveland has repaired and rehabilitated bridges over the last decade in a fashion similar to many other communities.

While bridges don't vote, the people who use them and depend on them do. Where bridges serve a clear constituency, they have been fixed. Cleveland resembles other cities in responding to bridge needs (as well as other major public facilities) in a crisis. Where an immediate need became obvious for a bridge that served an important need—carrying traffic to the stadium or to the downtown core—funds have been made available and the required repairs managed. It is fashionable to decry this sort of crisis response as bad management and poor planning, but it is a reasonable way to respond to expensive facility rehabilitation needs that cannot easily be forecast or justified to decision makers. The crisis response to bridge needs may well be a sensible form of natural selection, by which those structures that are relics of the nineteenth century, serving areas of the city that have been abandoned or depopulated over the years, are themselves abandoned and removed from the transportation system. Cleveland created a bridge network in the late nineteenth and early twentieth centuries designed to serve an industrial valley that was the city's economic heart. The jobs and industry that remain might well be better served by city expenditures on items other than the replacement of structures that were relevant in 1890.

CONCLUSION: DOES MANAGEMENT FAIL INFRASTRUCTURE? OR THE VALUE OF PORK

The historical record of a number of American cities indicates that infrastructure replacement and rehabilitation may be poorly

served by city management. Needs and standards have persistently failed to generate necessary capital funds, except in circumstances in which the political value of specific projects (e.g., urban growth or a new industrial plant) have provided larger interest and benefit. Management values based on limited-cost government, low taxes, and efficient service delivery have regularly ensured the deferral of street resurfacing or bridge replacement in favor of impressive public and private projects. This result has been supported by any number of local public works officials who have pressed for new construction projects over needed rehabilitation. Local support for new public facilities is not simply rooted in the vagaries of the federal grant system. It is a reflection of professional concerns and organizational interests. Change is possible in political systems. Some communities have acted to renew their capital stock and emphasize rehabilitation policies. Yet it is likely that these new policies simply reflect the latest trend and more vocal public demands and thus represent only a temporary shift.

The conditions of scarcity that have affected street resurfacing, storm drainage, and bridge replacement have regularly forced cities to choose among competing needs and competing locations. Simple criteria of efficiency under these conditions have resulted in clear biases in the outcome of decisions about facility improvement. The worst streets do not get resurfaced because they exceed a reasonable cost per square yard or because they are affected by a drainage problem that cannot be addressed. At the same time, streets that are seen as more visible or more important—in the downtown area, for example—are regularly repaved. The real national infrastructure issue may not be the deterioration of all our public facilities, but the fact that we can accept unpaved streets and basement flooding in some areas while insisting on excellent pavement conditions in others.

Politics offers an alternative approach to meeting infrastructure needs in a variety of neighborhoods. As long as elections can be won by resurfacing streets and votes can be gained from rebuilding sewers, infrastructure needs will be addressed. There exists a long political tradition of aggregating immediate local needs into a larger framework—the pork barrel. Although it is commonly derided as a political evil, the pork barrel system implicitly recognizes the value of local improvements and the need to provide them in a number of places. Spread public projects around so that a majority of elected representatives will gain, and there will be ample suppor

for a public undertaking. The result may be some loss in governmental efficiency, some projects undertaken that are less necessary or valuable than others. That may well be a very small price to pay.

REFERENCES

Boston Redevelopment Authority
1963 *Renewing Boston's Municipal Facilities.* Boston: City of Boston.
Cincinnati City Planning Commission
1949 *1951-1955 Program of Capital Improvements.* Cincinnati, Ohio: City of Cincinnati.
Cincinnati Highway Maintenance Division
1959 *1959 Annual Report.* Cincinnati, Ohio: City of Cincinnati.
Cogger, Janice, and Krumholz, Norman
1975 The Capital Improvement Programming in Process in Cleveland: Myth and Reality. Paper presented at the conference of the American Society of Planning Officials, Vancouver, British Columbia.
Durand, Edward D.
1898 *The Finance of New York City.* New York: Macmillan.
Gorham, William
1979 Foreword. In Nancy Humphrey, George Peterson, and Peter Wilson, *The Future of Cincinnati's Capital Plant.* Washington, D.C.: Urban Institute.
Howitt, Arnold M.
1976 Strategies of Governing: Electoral Constraints on Mayoral Behavior in Philadelphia and Boston. Unpublished Ph.D. dissertation, Harvard University.
Humphrey, Nancy, Peterson, George, and Wilson, Peter
1979 *The Future of Cleveland's Capital Plant.* Washington, D.C.: Urban Institute.
Koch, Edward
1982 Rotten at the core? *Barron's* June 7:9.
Rose, William G.
1950 *Cleveland: The Making of a City.* Cleveland, Ohio: World.
Stamps, Joseph L.
1971 *1971 Bridge Inspection Report.* Cleveland, Ohio: Division of Engineering and Construction, City of Cleveland.
Starbird, George
1972 *The New Metropolis.* San Jose: The Rosicrucian Press.
Werner, M. R.
1928 *Tammany Hall.* New York: Doubleday.
Wolfs, John R.
1968 *Report on the Status of Bridges.* Cleveland, Ohio: Division of Engineering and Construction, City of Cleveland.

DISCUSSION

Philip Dearborne

The three earlier chapters set the stage well for this one by Heywood Sanders on the politics of decision making about public works.

Joel Tarr makes it clear that we should not be panicking over th infrastructure issue. There is no emergency when the issue is see in a historical perspective. A century ago, 10,000 people per mont were moving into Chicago. The city not only had to install facilitie to serve them, but it also had to invent the facilities.

The second chapter, by O'Day and Neumann, suggests that muc of the needs issue is a media event. Trillion-dollar estimates of nee simply are not realistic. Moreover, the thought of digging up Ne York to replace all of its aging water mains is not realistic. We wi invent alternative systems before we tolerate that level of disru tion to urban life.

Peterson destroys the myth that financing mechanisms have major effect on infrastructure systems. This is well illustrated b the case of St. Louis, which is one major city on its way, as a matt of political choice, to having no bonded debt. In 1970 it had a de of $111 million; in 1981 its debt had dropped to $40 million and projected to reach only $7 million in the next 5 years. This is n due to major problems in the bond market. It is because the peop of St. Louis have not wanted to vote for bond issues, so St. Lou chooses not to borrow. Los Angeles is another major city in whi the constraints are political, rather than financial or legal. The constraints predate Proposition 13. Los Angeles has a legal de limit of $2.3 billion but has a current outstanding debt of only $ million.

Thus, we come to the politics of decision making. There are so clear deficiencies and so many biases in the system that we shou not pass over them lightly or refuse to try to deal with them. Clea the political system will make choices, and those choices are n always good. The repair of a major bridge might be deferred, instance, because the same amount of money will repair many mi of streets, making more people happy before an election. There a tendency to approach major public works through the domed s dium or convention center syndrome, thinking about the public involved and the community support engendered by spectacu projects, ground breakings, and dedications, rather than face future costs of operating such facilities. These real problems often masked by the fact that capital improvements and operati come from separate budgets. It is hard to resist the temptation the large project if money is available to build it, as, for exam in the case of federally funded multipurpose centers, even thou their purposes and how they were to be paid for were not know

The real question is how to perfect the system, to keep it wit

some reasonable guidelines for the allocation of available funds. One approach is to use the system of bond covenants more effectively. Another approach, which I always resisted as a municipal finance officer, is the use of earmarked funds for certain types of public works.

A possible research topic is the economic effect of bringing in capital from the outside the city, which is essentially what a bond issue does. It helps the local economy through the multiplier effect of public works expenditures. We need to know more about the utility of countercyclical financing of public works for cities, particularly those that are in bad fiscal shape. It may be that it would be politically and economically wise to borrow as a stimulus for economic development.

Scott Johnson

No city manager could agree with the conclusions of the chapter by Sanders. My principal problems with it are: (1) It does not adequately support its conclusion that whatever the political process produces is the best we can hope for insofar as allocation of resources to infrastructure needs is concerned. (2) It fails to address the real problem of politics in urban infrastructure. (3) Instead, it is content with a firm grasp of the obvious.

The paper certainly illustrates the point that politics controls infrastructure—what gets built, by whom, and how. I fully agree with that point. I do not agree, however, that politics in a micro sense—e.g., which street or sewer to build or repair—must be part and parcel of the political process or that a more rational assessment of needs ought to be secondary to the political process in making those decisions. Sanders seems to concur that those decisions should not be purely political. If not, however, then there must be some other basis for them, and the chapter provides us with no alternative statement of that basis.

Allocation of resources is always a political problem. Looking at his examples (and more cities could easily be added), Sanders seems to find that the allocation problems are easier in the growing cities than in those that are declining. This would seem to lead to the conclusion that the way for a city to solve its allocation problems is to grow. This is akin to the suggestion of Will Rogers that the way to eliminate the U-Boats in World War I was to bring the Atlantic to a boil and skim them off the top. Asked how to accomplish this, he said that he was the big idea man; it was up to others

to worry about the details. This approach to problem solving is als illustrated by the bumper stickers I see in Oklahoma that read: " you don't have an oil well, get one!"

It is indeed easier for growing cities to take care of their publ works problems. It is easier for politicians to extend the stree water, and sewerage systems into newly developing areas than is to maintain an aging, deteriorating system in an older area. Th problem is not so much one of dealing with differences betwee professional managers and public works administrators as it is or of how politicians deal with the public. So long as the maintenanc problems are invisible, so long as water comes out of the tap an disappears down the hole in the sink, it is hard to convince peop that their sanitary systems need major repairs or upgrading.

The discussion of the differences between Cleveland and Cincin nati is important. There is much discussion of the allocation of func to street repair. Streets are relatively easy to get funds for. Th real question is in comparison to what other facilities, how to a locate among facilities, and as to streets, which streets. The seriou political problem for any city is what to spend for streets and wha to spend for the police department and other functions in both th capital and operating budgets. Yes, these are political decision and the political decisions are often wrong. Our task is to improv the political process to change the nature of those decisions and th way in which they are made. This requires public understandin of the decisions. In both cities cited, the problem is one of prioritie In Cleveland the highest priority was to dispense the goodies to th neighborhoods of the council members. This is a result of the war system. In Cincinnati, with no ward system, the political proce recognized that streets were not the highest infrastructure priorit

I do not think that the solution to the urban infrastructure pro lem is to return to the approach of Boss Tweed minus the corruptio At the micro level, such as the ward, purely political decisions c not result in the maximization of benefits to the community as whole. If a city has a ward system, it may be necessary to stret to justify street repair projects that merely ensure that each war gets its share of the gravel and asphalt. Because streets are obviou to the citizen and sewers are not, streets get resurfaced that do n need it, while the repair of sewers beneath them is neglected.

Sanders admonishes us that allocation of resources is politic and that we must work within the political system to deal wi infrastructure problems. It does not tell us how to do that.

Henry Gardner

I read this chapter twice. After the second reading, I suggest that it be retitled either "Pork Barrel Politics Solves Infrastructure Problems" or "Cleveland: A Model for Local Government."

I am not sure where the chapter is headed in its description of the differences between the newer, growing cities, such as Phoenix, and the older cities, such as Oakland and Cincinnati. Growth does not help manage the problem of infrastructure for cities that are not growing. The reason is that there is a variety of ways to pay for the expansion of facilities. When there is growth, expansion is relatively painless, as the growth in volume and values allows the costs to be absorbed. When facilities are self-financing, they may also be provided with relatively little pain, so long as the costs are spread widely or to a clientele that can afford the cost and wants the service. When they must be financed by taxing those who already have services or to whom the new services will not be available, the political task is infinitely more difficult.

The chapter by Sanders suggests that we ought to look more carefully at the performance of strong mayor and manager cities. I would hypothesize that we will not find major differences between them, although I think that that question should be examined. It is more important to compare the approaches and capacities for dealing with the infrastructure problem of the older cities that are not growing with those of the newer, growing cities.

I think the chapter deals with the politics of decision making in too narrow a context. Cities provide not only facilities but also a wide range of other services that the public demands. The political problem is one of balancing among these services and facilities; balancing competing needs, such as police, libraries, parks, streets, etc. We need to look at cities like Cleveland, Oakland, Boston, and Cincinnati to identify their degrees of success in this balancing act. I am frankly surprised by the conclusion that the way to do this is to return to the approach of Boss Tweed, minus the corruption.

Let me make some comments from the perspective of one state—California—that is not interested in returning to the style of either Tammany Hall or the Cleveland Council. California has been a leading state for improvement of the processes of representative government and also for an untainted decision-making process.

After the adoption of Proposition 13, California cities had to contend with drastic reductions in funding sources. The state itself

must now face dwindling resources. In the case of Oakland, th availability of funds is a central problem. We could have taken th position that money for some things could be found by closing ou libraries and shutting down some fire stations and other facilitie But that is not the way cities function. After Proposition 13, Oak land lost 25-30 percent of its funds. This occurred after it had a ready reduced its budget in the preceding 2 years by 10 percen What we had to do was balance competing needs, all of which coul be justified. We closed a fourth of our libraries and several fir stations. This produced a great public outcry. We reduced our polic force by 100, also over considerable public opposition. The Sande chapter suggests that our city is on a 100-year cycle for road re surfacing. That is not true—we are on a 200-year cycle. The poir is that we had to look at all manner of needs and costs and strik a balance among them.

One could argue that this is only a problem for the older, poore cities. That has not proved to be the case in California. Since Pro osition 13, few new taxes have been adopted, even in wealthy, ho mogeneous communities. Two of our wealthiest cities, Hillsboro an Piedmont, have refused to increase their school taxes. The point that the public is not willing to pay for it all, so we have to decid what to continue to provide.

The alternative approaches to the political process appear to b these:

(1) Dig up the ghost of Boss Tweed.
(2) Do what the paper suggests: Use a system of pork barre politics that rewards certain groups and neighborhoods an proceed in a patchwork fashion.
(3) Keep doing what we have been doing—following a systen atic, engineering approach—hoping the public will eventu ally get the message.
(4) Wait for the system to collapse, on the assumption that th public will then realize that something must be done and wi be willing to foot the bill for it.
(5) The approach I recommend: Deal directly with the fact tha people do not want to pay more by:

a. Improving the image of government. We must work t regain the confidence people have lost in the capacity of go ernment to act effectively and fairly in solving communit problems.

b. Educate the public on the needs. We must bring hom

the facts, solicit the support of business and community groups, use the specific examples of problems as *symptoms* of the total problem, and develop comprehensive plans for resolving it.

c. We must push our mayors and council members to marshall their forces and to take a more active leadership role. There never is a good time to raise taxes. Too often when cuts in critical infrastructure systems like sewers are suggested, there is no Friends of the Sewer to rally support, as there are the Friends of the Library, the Museum, and the Parks. The proper balance cannot be found for the city as a whole when some of its crucial facilities have no supporters until they collapse.

Finally, we must look to creating financing mechanisms to deal with some of our problems.

SUMMARY

Does the Political System Doom Us to a Substandard Level of Service?

In some respects the message of the chapter and discussion is that the political system, as it has developed and as it works, produces a substandard level of service. The tendency of the system is to postpone decisions and to defer maintenance. Yet the engineering and financial studies tell us that we should not wait, that money can be saved through fixing things in time. Is there no way to avoid this dilemma?

While there was no clear answer to this question, the point of the Sanders chapter is that for the system to work it is necessary for the interests in infrastructure to be advanced by people who seek some immediate, direct, and personal reward. Only then can these interests compete with others that have such advocates. One way of mobilizing these latent interests is to make information available about exactly what delays will cost. The political system provides the best channels for doing that—a difficult and often nasty system of trade-offs. While it is more economical to perform preventive maintenance, the basic reality is that these modest investments are often sacrificed. While it is surely accurate that decisions should be more efficient, making them may require real evidence of the consequences of neglect before people understand the costs and demand action.

The Role of the Public Works Professional and Manager

The boss system is based on an assumption of an endless cornucopia of money. Like sending a drunk down an alley, it is likely he will get to the other end, but not in a very efficient manner. It is the public works professional's role in the political process to try to provide some rational priorities so that resources can be conserved and the important issues are not ignored or glossed over.

The pork barrel works when there is rapid growth, when resources are expanding. Even in strong traditional boss cities like Chicago, the machine began to get into trouble when growth in resources began to slacken. Even Mayor Daley was in trouble by the end of his tenure as federal money for the city declined. As finances declined, so did his total power, and centrifugal forces began to rip the machine apart, since not all elements could continue to be pacified with the resources available. The last two mayors who inherited the machine have been defeated.

Someone has to pose the central questions to the elected officials—and that is the key responsibility of the public works professional. When department heads forget this role and instead become mere political brokers, they assume inappropriate roles. Savannah, which has a politically strong mayor and an effective city manager, also has had a stable political system. The city has developed a professional system of condition assessment and planning that has permitted it to order its priorities in the face of declining resources. This approach has worked politically. The mayor has just been elected to his fourth term. Good staff work has allowed him to make political promises and to keep them. The old boss system is very inefficient, and such inefficiencies can no longer be afforded.

Public works professionals are responsible for logical engineering and management analysis. They have to bring more reality to the decision-making process, so that the ultimate decision makers will weigh competing priorities and so they can understand how they must marshall their resources to gain acceptance of the necessary decisions. To do this, public works professionals must be sensitive to the political process.

The Need to Understand the Trade-Offs

Both public works professionals and politicians must recognize the changes that have taken place in public expectations with re-

spect to levels of service. These have to be reconciled with the fact that current resources do not permit a dramatic increase in services. Therefore, service levels will have to change. An important problem is how to bring more rationality to the process of making those trade-offs. This requires improved information as well as an improved process by which the information is translated so that department heads, political leaders, interest groups, and the general public can understand what the choices are.

One serious problem in improving the use and translation of information is the tendency to rely on anecdotes as evidence, and particularly on inaccurate anecdotal information. Boss Tweed, for instance, did pave a lot of streets. But he also left the water system in bad shape and built dams with severe structural defects. Many of his projects were dismal failures. Such examples of political decisions that are uninformed, poorly informed, or misinformed by professionally developed technical information are not relegated to the nineteenth century; some are of recent vintage.

The Engineering Brain Drain and Local Public Works Decisions

The role of planners and managers in the decision-making process has increased, while that of the professional engineer has declined. In part this seems to be a result of the movement of many engineers away from public works professions into the newer aspects of engineering. Space, electronics, and environmental engineering have attracted more of the better engineers. We are not now training as many engineers for careers in local and state governments. The growth of the regulatory control and the openness of that process has also made the decision-making process more difficult for the traditionally trained engineer to negotiate. The growing complexity of the process demands that the engineer be more rational and more competent. It is unlikely that the current decision-making system could support a great intuitive public works leader such as Robert Moses.

5

The Future of Urban Public Works: New Ways of Doing Business

Douglas C. Henton and Steven A. Waldhorn

INTRODUCTION

Two or three decades ago, the world of urban public works seemed for the most part to be set in concrete. Financing methods were standard, engineering designs uniform, and politics mostly local. Starting in the mid-1950s, however, cracks began to appear in that concrete, and recent developments have speeded up the crumbling of the urban public works foundation.

Beginning in 1956 the federal government first increased, then decreased, its involvement in such areas as interstate highways, wastewater treatment, and mass transit construction. Over the same period, deferred maintenance has presented the country with a huge bill—now coming due—for repair and construction. In the last few years, fiscal constraints have forced localities to abandon traditional financing approaches and to search for new ways to fund public works.

In this context, infrastructure has within the past year or two been discovered as a national issue. The once fairly traditional arena of public works is being forced to adapt to new realities. Federal, state, and local roles, as well as the nature and extent of private-sector involvement in infrastructure issues, are being re-thought in a fundamental sense. There is debate regarding how funds for capital improvements should be raised and spent at every

level of government. New political alliances are emerging around these issues. Finally, at least some new technologies seem to have developed to a point at which they can significantly affect both the cost and design of some public works. In short, there is a new world of urban public works and a future that requires new ways of doing business.

This chapter examines these new ways of doing business from the diverse standpoints of economics, politics, and technology. It draws in large part on research here at SRI International. We try to identify some of the major questions that research in this area should address over the next decade.

From an economic point of view, some questions requiring investigation include:

- What types of financing methods to pay for infrastructure are likely to become more prevalent?
- Is there a significant shift in the willingness of people to pay for different kinds of facilities and services?

From a political point of view, some basic questions need to be addressed:

- Which stakeholder groups are likely to support increased investment in public works?
- What new coalitions are likely to emerge on different sides of issues, and what new roles can we expect to see for business in this issue?

Finally, from a technological point of view, critical questions that need to be looked at include:

- How will new patterns of urban development linked to new technologies change demands for infrastructure of different types?
- What potential innovations in public works technology are likely to occur and what are likely to be major constraints to their adoption?

We conclude that public financing for infrastructure is likely to become more benefit-based and user-oriented, moving away from traditional tax and spending approaches. New types of public-private options will become more prevalent. Research is needed to assess the equity effects of these new methods of finance and to determine how extensively they can be applied.

We also find that new political coalitions are merging around the

infrastructure issue, often involving a special role for business the state and local levels. Infrastructure may be seen less as sole a government issue and more as an issue of public-private inves ment. Research is needed to determine the consequences of the structural changes and opportunities for joint investment.

Finally, we suggest that current demands to rebuild our decayi infrastructure may not be taking into account new patterns of urb development and new technology, which call for very different kin of investments in public works. Research is needed to determi how critical developments in technology will shape demand for i frastructure and how technology innovation can be promoted in t provision of infrastructure.

INFRASTRUCTURE AS AN IMPORTANT NATIONAL ISSU

Infrastructure will remain a national issue because the proble is going to get worse, and there is little indication that the ro causes are going to be addressed soon. State and local financ cannot deal with the problem without major changes. The bas tension in this issue for the future is determining who is responsib for what. Is infrastructure a national, local, or state issue, and wh role should the private sector play?

A second question, only beginning to emerge, is how much i frastructure can we afford, and of what kinds? For example, is mo new industry likely to be attracted by a better highway or by t installation of broadband data transmission lines and microwa facilities? If local phone companies die, will municipalities be r sponsible for telephone service as well as sewers?

Visible Signs of Decay

In 1982 infrastructure went from an obscure term known to on a few into the national spotlight. It is likely to remain high on t national agenda for a number of reasons. The causes of the pro lems—deferred maintenance and inadequate public investment are likely to continue at least into the near future. More recent the public has become aware of visible signs of decay, notably the form of potholes, breaks in water mains, and bridge closing The media have picked up on these visible signs and dramatiz the worst cases in articles and news stories.

The business community has become especially concerned abo this decay because it recognizes how critical infrastructure is f

its own future development. Most studies of business decisions to locate plants and facilities put adequate infrastructure near the top of the list of factors influencing decisions (Choate and Walters, 1981). Adequate roads, water systems, transportation, and sewers are essential to business. While the current recession has slowed company expansion and capital outlays, business can look ahead and see potential bottlenecks and constraints on its growth and development. A recent news article on infrastructure questioned the ability of local governments throughout the nation to provide the infrastructure needed for economic growth (*Business Week*, October 26, 1981:7-9). Although there is controversy over the extent of infrastructure needs, few observers question that the task is one of major magnitude.

Deteriorating State and Local Finances

Concern about how to pay for infrastructure has increased with the deterioration of state and local public financing. Beginning with the tax limitation movement heralded by Proposition 13 in 1978 and continuing through 1983 with the effect of the recession on revenues, state and local governments throughout the nation have been experiencing extreme fiscal constraints. The response has been to cut services. Since 1978 per capita state and local expenditures have declined steadily in constant dollars (U.S. Advisory Commission on Intergovernmental Relations, 1981). At first, like the public, business saw the cutbacks mainly as a move to reduce the fat in government; now the perception is that of being down to the muscle and bone in some services. For example, a recent poll conducted for the Bay Area Council in California by Mervin Field (Field Research Corp.) found that for the first time since Proposition 13, a majority of Bay Area citizens felt that cuts made in local budgets after Proposition 13 were in the wrong places and that taxes should be raised, if necessary, to maintain municipal services. A question that many municipalities are grappling with is how operating and capital investment costs should be paid for in the aftermath of the tax limitation movement. A longer-term question is how much long-term investment should be made.

A National or Local Issue

While infrastructure has become a national issue, public works still remain primarily a local concern. There is a basic tension

between forces that centralize this issue at the federal level an forces that decentralize it to the community. During the 1950s an 1960s, there were strong centralizing forces resulting from suc acts as the creation of the interstate highway system and federa grants for urban mass transit and wastewater treatment. In th 1970s, growing concerns about an overloaded federal system an budget deficits led to moves to decentralize and reduce federal e forts. By the 1980s, growing fiscal constraints at the local leve have limited the ability of local government to finance capital im provements. Today there is a basic problem of increased federa financing accompanied by federal standards versus local adaptatio to regional differences.

The next few years should provide an opportunity to sort ou some appropriate roles for federal, state, and local governments a well as the private sector in infrastructure. It is important to avoi first, too many national standards that do not allow for necessar regional variation and, second, local adaptation so decentralize that there are tremendous inequities by region and among servic areas. How to avoid these traps is one of the most important que tions the infrastructure debate will address in the future.

SOME FUTURE TRENDS IN URBAN DEVELOPMENT AND TECHNOLOGY

Changing technology is affecting urban development and the typ of infrastructure that will be needed. At the same time, new tec nology is changing the way infrastructure can be provided. Thu engineering and technology affect both the demand for and th supply of infrastructure. Those relationships need to be examine more fully to understand what types of public works will have t be paid for in the future.

Future Development and Public Works

Infrastructure is both a consequence and a cause of urban de velopment. The evolution of urban public works shows a clear re lationship between changing spatial dimensions (urban sprawl, fo instance) and infrastructure. New technology (e.g., railroads, au tomobiles), energy resources, and work and housing patterns a interrelate and determine the types of public works that are neede Urban development from 1880 to 1920 demanded one type of cer

tralized infrastructure, while the suburban developments of the period 1950-1970 determined a different, more decentralized type of public works. What type of urban development can we expect in the future and how will these patterns determine the types of infrastructure that will be needed?

In many ways these basic questions of urban development and new technology are not being asked today in planning for public works. A large part of today's problem is repairing what has already been built and thereby preserving the investment in public works. The only controllable part of today's problem seems to be what type of new infrastructure investments we want to make for the future. However, rebuilding the nation's decaying infrastructure exactly as it is may be like refighting the last war instead of the one we really face. Perhaps we should instead be investing in new types of infrastructure—even for old systems—for the emerging economy of the United States.

One way to deal with the question is to say that changes will come slowly and tomorrow will look pretty much like today. The implication is that the necessary adjustments can be made as we go along. Another way to look at this question, however, is to relate infrastructure demand to future scenarios that are different from today. SRI has used these types of scenarios to explore possible future developments in such areas as transportation and energy (SRI International, 1977a, 1980a). In laying out future scenarios, it becomes possible to explore the relationships between technology, urban development, and infrastructure requirements.

One future scenario is based on the continued emergence of the postindustrial information economy. Increasing numbers of workers are employed in high-technology, services, and information-related fields; the application of computers changes the nature of work. These developments combine with major advances in telecommunications to drastically change the patterns of both urban development and work itself. Businesses that communicate information by satellite no longer need to be concentrated in central cities. Increasing numbers of people can work at home using computers connected to their telephones to do their work. It is estimated that as much as 7 percent of the labor force will work by using computers at home by the end of the century. With workplaces more widely distributed instead of concentrated, there would be less commuting to work and lower demand for highways. The shift toward high-technology information services that would reduce the demand

for heavy industrial infrastructure would also increase the demand for communications infrastructure. This pattern of development thus drastically alters needs for public investment: Are today's public works planners preparing for it?

The Japanese have been giving this type of future and its implications for infrastructure some serious thought. A recent journal of the Ministry of International Trade and Industry described how changes in Japan's industrial structure require a new type of infrastructure. It states: "Our industries have shifted toward knowledge-intensive and high value added industries. . . . The high technology industries require an infrastructure remarkably different from those required by the industries leading our economy in the past. . . . Increasingly, a 'soft' infrastructure organized around the demands of the information has become important" (Kobayashi, 1982:2).

New Technology of Infrastructure

Another scenario is based on the assumption that new technology for providing infrastructure will emerge. New, less-expensive road surfacing methods and materials, alternative bridge construction, and new water system methods are becoming available. New types of community waste treatment, solid waste disposal, and heating systems are developing. Some examples of these technologies from recent research at SRI include new membrane separation techniques that can reduce the level of organic waste that has to be treated and new uses of polyurethane to reinforce bridges (recently used on the Golden Gate Bridge).

A particularly interesting innovation is the development of a noncorrosive substitute for salt made from biomass feedstocks such as corn. In a recent report for the Federal Highway Administration prepared by SRI, methods of genetic engineering are described for creating a mutant strain of bacteria critical to the fermentation process for producing a substitute deicer, calcium magnesium acetate (SRI International, 1982a). A recent article in *Chemical Engineering* states that "biochemical technology could well prove a major weapon against the deterioration of our roads, bridges, rails, autos, and other steel structures (*Chemical Engineering*, 1983). The article notes that a major cause of the decay of these structures is the use of salt—about 9 million tons annually. The Federal Highway Administration is now sponsoring efforts to develop methods for producing calcium magnesium acetate economically.

An important question is whether local governments can adapt to new technology. Research by SRI for the National Science Foundation on the adoption of science and technology by state and local governments indicates that a variety of institutional, political, and economic constraints stands in the way (SRI International, 1980b). Chief among those constraints is that bureaucracies tend to be dominated by those who have a low propensity to innovate, at least partly because there is an absence of rewards for risk taking. At the same time, economic factors work against adoption. SRI's work on transportation in the future found that "increasing cost and risk associated with introducing a new technology on a grand scale seems certain to slow down its acceptance and diffusion" (SRI International, 1977b:3).

Suppose both scenarios apply to some degree, so that there is a situation in which some new types of infrastructure will receive more emphasis (satellite networks) and others less (new commuter freeways) and in which new technologies will be used in repairing aged systems. The question then is, are we up to it? Robert Yin has found that technological innovation can be promoted at the local level, if the particular innovation can serve bureaucratic goals and economic self-interest (Yin et al., 1976). Thus the key to this scenario seems to depend on the political, bureaucratic, and economic characteristics of local governments.

A recent SRI effort to transfer space technology illustrates some of these issues. The National Aeronautics and Space Administration had developed a new automated water quality monitoring system that had application to municipal water supply systems. This technology had been tested at the Santa Clara Valley water reclamation plant. SRI's technology applications team sought to transfer this technology to other localities. For the most part, cities and counties were not ready to adopt it because they had not adopted recycling methods that made the new technology economically feasible and thus considered the cost of this new technology too high. Two cities that did adopt the technology, Denver and Houston, had decided that the economics of water required recycling methods and saw the value in purchasing this automated approach (SRI International, 1981a). In this case the acceptance of new technology was linked to the economics of water systems and the willingness of local government officials to change approaches.

Even old technology can be difficult to implement. An example of a technology that is itself not so new but is innovative for most U.S. communities is district heating and cooling. While a number

of European cities have district systems, few U.S. cities do. P ponents of district heating point out that it is economical in tha reduces the need for large numbers of individual systems and energy-efficient in that it can burn a wide variety of materials w less waste. Why then is it not readily adopted by cities that ne more economical and energy-efficient heating systems? One barr is the institutional complexities involved in obtaining agreeme from the multiple owners of user facilities so that specific proje can become economically feasible. Another is that current pub policies do not encourage citywide district heating developme Existing utility companies do not see the need to get involved such developments. In short, institutional, economic, and politi constraints plus the general weight of prior commitments to exi ing systems make massive redesign of heating and cooling syste difficult. Changing economics and growing awareness of the opti may alter this situation in the future, but for now constraints blo action.

This problem of checks on new developments, innovation, a risk taking is described in more global terms in Mancur Olso recent book, *The Rise and Decline of Nations*. The growth in t number of organizations and interest groups committed to prese ing the status quo (or at least their piece of the pie) acts as a che to innovation. In terms of infrastructure, there is a risk that peo may be so committed to existing technologies and approaches th they cannot adopt new approaches that are more suited to futu needs.

An Infrastructure for Infrastructure Innovation

Research by SRI for the National Science Foundation has fou the importance of a research and development "infrastructure" linking research and development to users (SRI International, 1977 Recent research on the adoption of innovations has pointed out t key role that an infrastructure of intermediary institutions can pl in helping to translate new technology into forms that are use to adopters (Brown, 1982). In the area of public works, there clearly a need for networks for the diffusion of innovations in te nology. Research on innovation diffusion has indicated that te nical and scientific professional groups can help to perform a use function in this regard (Bingham et al., 1978).

One example is the engineering profession. A recent article (*Ci*

Engineering, 1982a) on infrastructure and the role of the civil engineer points out that engineers have an important role in accurately assessing needs and developing innovative and more cost-effective techniques to renew and rehabilitate infrastructure. A later article (*Civil Engineering*, 1982b) points out that civil engineers have a direct impact on codes, regulation design, contractual risk sharing, and technological innovation, all of which have a major impact on cost. Civil engineers along with transit designers and public works experts need to become a force in promoting technological innovation and more cost-effective methods. This could involve a greater focus on innovation in career training and development. In general, it may be useful to think about new ways to promote better infrastructure for infrastructure innovation.

Engineering and technology are only part of the triad of concerns involved in infrastructure. As we have seen, economics and politics also shape the adoption of new technology.

THE SEARCH FOR CREATIVE ALTERNATIVES

Benefit-Based Approaches Versus Ability to Pay

No matter how many different types of new infrastructure are built in the future, one thing is clear: New ways to pay for them are needed. Major changes are occurring in public financing for public works. Chief among these has been a shift toward user-oriented, benefit-based approaches. Since the time of Adam Smith, political economists have argued the virtues of a benefit approach to public finance, whereby those who benefit from a service pay for it. Concern over equity led John Stuart Mill and others to argue for an ability-to-pay approach, in which each should pay for a service according to his or her ability to do so. Thus income and property taxes are based on an individual's financial resources. The twentieth century saw a rapid increase in the use of a broad range of taxes based on ability to pay. Then came the taxpayers' revolt, initiated by Proposition 13. A variety of benefit approaches are on the rise. A recent survey by the Municipal Finance Officers Association and the Advisory Commission on Intergovernmental Relations found a 77 percent increase in user charges and a 26 percent increase in benefit assessments by cities in the United States (Cline and Shannon, 1982). When the U.S. Advisory Commission on In-

tergovernmental Relations (1982) surveyed the public, asking wh
method is the preferred way to raise revenue, 55 percent ch
charges for specific services and only 5 percent chose to raise pr
erty taxes (21 percent chose to raise sales taxes). In this phen
enon we see a return to basics in public finance—the link betw
services and taxes is reestablished.

How does this evolution in public finance toward benefit-ba
approaches address issues of equity? Not very well, if equity
defined in terms of ability to pay. Anthony Pascal of the Rand C
has suggested equity-based charges that take into account the us
income. This can be done either directly, through discounts, or
directly, through rebates or credits on taxes. Any solution to
equity problem, however, will create problems in administrati

Finally, one of the advantages of a user charge is its link
efficiency. Consumers use public services more efficiently if th
know they have to pay for them. User charges will thus rel
consumer demand to supply more effectively. Here, then, is
classic trade-off in economics: equity versus efficiency.

The Impact of Fiscal Constraints: A New Role for Local Government

Some have called California a bellwether state in the past, a
it may well be leading the way in new approaches to infrastructu
Recent studies of infrastructure options by the Bay Area Cour
and the Association of Bay Area Governments, from the local p
spective, and by the Governor's Office of Planning and Resear
from the state viewpoint, indicate the type of rethinking that h
been going on (Bay Area Council and Association of Bay Area G
ernments, 1983).

First, Proposition 13 has forced local officials to consider alt
native ways to finance public works. The ability to raise prope
taxes was sharply curtailed, and the issuance of general obligat
bonds was limited. This has led to a move toward benefit-bas
user-oriented, pay-as-you-go approaches. Second, current bud
crises (arising as much from the economy and federal grant cutba
as from tax limitations), have made local governments look m
seriously at ways to work with private business as a partner
solving problems. Infrastructure is a natural area for collaborat
with business, because business has so much to gain in terms
the effects on economic growth. New types of public-private
rangements have been emerging.

Business has shown increasing willingness to support public works not only through taxes and benefit-based revenue approaches (e.g., user fees, benefit assessments, developer contributions), but also through direct participation in infrastructure development and provision. The MFOA-ACIR survey also found that cities had expanded their use of "privatization" options: 24 percent had increased developer contributions to infrastructure; 17 percent had increased contracting out (Cline and Shannon, 1982). A recent review of infrastructure financing in California prepared for the California Tax Foundation found increasing use of bargaining between the public and the private sectors over infrastructure provision, with developers increasingly providing public improvements as a condition for gaining approval of a development (Kirlin and Kirlin, 1982). Private businesses are also increasing their contribution to infrastructure development as an investment opportunity with substantial tax advantages through sale-leaseback arrangements. There is every indication that this trend will continue—a trend that has major implications for the changing nature of governance.

The traditional role of local government as a tax collector and provider of publicly financed services is being replaced by a newer role of local government as entrepreneur, catalyst, collaborator, and broker with the private sector. In some cases, citizens are paying directly for services through user fees or benefit assessments; in other cases, developers are paying through exactions and fees. In still others, private businesses will share the investment cost (and possibly gain some tax benefits). A fairly straightforward tax and general obligation bond financing system is being replaced by a much more diverse set of financing measures: tax, fee, developer exaction, revenue bond, certificate of participation, and sale of leaseback. In the process, local government is learning how to use its powers of governance (regulatory, tax, administrative) in addition to its spending powers to achieve local ends (SRI International, 1980c). The consequences of this creative adaptation for both public finance and public administration are immense. Let us look more closely at some of these local alternatives.

Alternatives in the Bay Area

In November 1981 the Bay Area Council (which represents over 300 businesses in the San Francisco Bay Area) joined the Association of Bay Area Governments (which represents over 500 local governments) to address the infrastructure issue. A public-private

task force began working on the problem with assistance from
(Bay Area Council and Association of Bay Area Governments, 19
After documenting the scope of the problems involved in local str
and roads, water treatment, local drainage, water supply, and p
lic facilities, the group began the difficult task of identifying
ternative financing options. Proposition 13 has limited local g
ernment's ability to raise local property taxes or issue additio
general obligation bonds. The state government is experienc
budget crises due to the effect of the recession on revenues and
impact of federal budget cuts. A new range of alternatives fo
nancing infrastructure beyond traditional tax and borrowing st
egies is needed.

The task force began identifying options within three gene
categories:

- revenue-raising techniques;
- debt methods; and
- public-private approaches.

Within each category individual options were analyzed usin
common set of criteria:

- adequacy of funding;
- equity;
- economic effects; and
- ease of public administration.

The initial search for alternatives focused on what could be d
under current law at the local level through action either by lo
government or by business. Based on this analysis of options,
group developed a set of feasible alternatives that local gove
ments can now use to help address infrastructure financing iss
(Table 5-1).

The Bay Area Council/Association of Bay Area Governments t
force has now moved into the implementation phase, beginning w
the sharing of study findings with local government and busin
leaders and the encouragement of local governments to adopt r
approaches.

What is most striking about these alternatives and what t
mean for future directions in the financing of infrastructure (
possibly local public finance generally) is their clear orientat
toward benefits-based user payments, private-sector participat
on an equity basis, and a public-sector role as entrepreneur.

TABLE 5-1 Infrastructure Financing—Alternatives in the Bay Area

Revenue Options

- Development Fees and User Charges—This conventional approach to raising local revenues could be expanded.
- Benefit Assessments—Establish special districts to pay for public facilities by assessing a levy on property owners in the district.
- Community Facilities Districts—Establish local districts to enact special taxes to pay for certain public facilities and services.
- Redevelopment Authority—Finance new construction in redevelopment areas using property tax increases from rising property assessments (tax increment financing).
- Special Taxes—A revenue source identified in Proposition 13 that local governments may use for specific purposes after approval by a two-thirds vote.

Debt Options

- Revenue Bonds—Bond issues are linked to enterprise activities that will generate dedicated sources of revenue to pay off the bonds.
- Certificate of Participation Lease Financing—Certificates (representing interest in leases to public entities) are sold to private investors to raise funds for new facilities. Certificates are also used in combination with sale and leaseback arrangements.
- Creative Use of Bond Instruments—This involves unconventional or nontraditional aspects of bond financing, such as zero coupon or indexed bonds.
- Short-Term Money Management—Various investment techniques are used to produce maximum return on local government funds.

Public-Private Approaches

- Private Contributions—Contributions can be sought from citizens and private businesses for public facilities and their operation and maintenance.
- Private Enterprise Licensing—Exclusive rights can be granted to a private firm to construct and/or operate certain facilities.
- Public Sector as Entrepreneur—Local government can operate as if it were a private firm, e.g., jointly participating with business in new developments. Local government can bargain with developers to pay for certain facilities in return for public investment and development permits.
- Sale and Leaseback—Newly constructed or existing facilities can be sold to private investors and leased back for public use.

The implications are that local government can no longer be solely an administrator of local taxes and intergovernmental grants, that private business must become more directly involved in financing through means other than local taxes, and that citizens must be prepared to pay directly for the services they receive. As the change progresses, we find government acting more like a business in many areas, residents paying set prices for public services, and businesses becoming more involved in providing those services and facilities. A critical question is the extent to which these alternatives will become more dominant in the future.

Innovation in Urban Transportation

An example of one area in which these types of alternatives ar being actively experimented with is urban transportation. Te Kolderie of the Hubert Humphrey Institute has suggested that, i addition to the choices of raising taxes and reducing services, third option is available to local communities—redesigning an restructuring services (Kolderie, 1982).

Kenneth Orski has outlined some of the major changes in th recent American Enterprise Institute's review of private-sector in itiatives. He sees a move away from the traditional view that th delivery of local transportation services should be the exclusiv domain of tax-supported public agencies, toward an emerging beli that government itself need not deliver all services.

This change is evidenced in the growing number of communitie that are contracting portions of their public transportation an encouraging entrepreneurial transit. It is seen in the growth o nonprofit transportation user organizations (commuter bus clu and regional ride sharing) and corporate employee transportatio programs. Increasingly, private developers are sharing in the ex penses of infrastructure improvements in transportation. In som cases, developers are granted construction or zoning permits on th condition that they implement programs to minimize the effect o increased traffic on surrounding roads. In other cases, private bus ness is contributing directly to highway improvements. In Dalla real estate developers are contributing to the construction of a ne light rail system by donating most of the system's right of way. I New York, a private business purchased mass-transit rolling stoc and leased it back to the mass transit authority, thereby gainin tax advantages under "safe harbor" leasing provisions. Overal Orski (1982) has found that these new types of public-private par nerships "may be the vanguard of a new form of governance— new grassroots approach to local problems that is neither full public nor fully private, but is instead a merging of public an private interests in new institutional settings."

Sale-Leaseback

The 1981 Economic Recovery Tax Act created new opportunitie for business to purchase and then lease back capital to local go ernment and thereby gain tax advantages under accelerated d

preciation. Especially in the area of mass transit rolling stock, businesses have taken advantage of so-called safe harbor leasing for tax credits. In other areas, businesses have been able to negotiate arrangements with cities for the purchase of a capital facility that is then leased back to the city. Sale with leaseback has opened up new possibilities for profitable business participation in infrastructure development. Public-private partnerships can help local government raise additional resources for public works improvements using sale-leaseback arrangements and negotiated developments based on mutual self-interest.

The blurring of boundaries between the public and private sectors is especially unusual in one form of sale-leaseback arrangement—the tax-exempt leveraged lease. In tax-exempt leveraged lease financing, local governments sell public facilities in order to generate capital funds for construction and rehabilitation. The sale is financed by tax-exempt revenue bonds. Once the facilities are sold, the municipalities lease them back at low rates that reflect tax benefits gained by private purchasers.

Looking more closely at the mechanics of one example—Oakland, California—shows what is possible and how it can work to the benefit of both local government and the private sector. Oakland needed to spend $10 million to renovate a deteriorating public auditorium. After a review of financing options, the city decided that sale-leaseback financing combined with tax-exempt revenue bonds not only offered the lowest borrowing cost but also required no general fund monies.

In the initial phase of this transaction, the city sold its art museum to private investors for $22 million, financed with a 5 percent down payment and a $22,240,000 bond issue. In the second phase, the auditorium was sold for $20 million plus cost of renovation. That purchase was financed through industrial development bonds. The city entered into a 30-year lease with four 5-year renewal options. As a result the city continues to control management of both facilities. At the end of the lease and after the first renewal period, the city will have the opportunity to repurchase the museum and the auditorium. Upon expiration of the leases, the city intends to reacquire the facilities.

This leveraged lease financing allows the city to sell public facilities to investors in order to use the proceeds to finance the rehabilitation of the auditorium. Measured in terms of savings in the cost of borrowing, these two transactions provide a cost of leasing

approximately 1.7 percent below the interest rate on Oakland's conventional tax-exempt revenue bonds. The net gain to the city from both lower borrowing cost and proceeds from the sale is over $42 million.

By purchasing the facilities, private investors obtain the tax benefits of ownership in terms of accelerated depreciation. These tax advantages are reflected in the lower lease payments. Thus, both the local government and private investors benefit from this arrangement. The types of facilities suitable for tax-exempt lease leveraging include schools, museums, community centers, ports, airport facilities, warehouses, office buildings, and other real property. This type of financing arrangement underscores the growing interdependence of the public and private sectors in the area of urban public works (Goldman Sachs & Co., 1982). It also raises a series of fundamental questions about the distinction between what is public and what is private and the use of the tax code to finance public capital investment.

State and National Alternatives

Clearly not all infrastructure problems can be addressed through local solutions. It is important to point out, however, that a problem deemed national in scope does not necessarily require a single national solution. In the case of infrastructure, what is viewed as a national problem is really an aggregation of many different problems. Therefore, state and national alternatives should be pursued with this need for diversity in mind.

What is the proper role for state and national government? The biggest problem facing localities that requires outside assistance is access to credit. Most states have better credit ratings than their cities. They are able to reduce overhead costs by packing the borrowing for several projects into a single bond issue. Thus, one area in which states can help localities in infrastructure is the use of bond banks.

State Bond Banks

The State of New Jersey is considering the creation of an infrastructure bank that would help localities finance sewer systems, water supply, and recycling facilities. It would get start-up capital from current federal government grants and state bond issues al-

ready authorized but not yet obligated. Local governments receiving loans from the bank would have to agree to raise user fees to help finance the repayment of the loan. The advantages of this direction in state local assistance are clear. Economies of scale favor state borrowing; state loans are paid back when grants are not, and localities can design and operate their own infrastructure.

Federal Public Works Bank

If an infrastructure bank would work at the state level, why not at the federal level? A proposal has been developed for a national public works bank into which the federal government would put $1 billion and the states $1 billion. The federal government would use the $2 billion to borrow $20 billion that states could lend to their localities for infrastructure projects. On one hand, the argument is made that the federal government would be able to borrow money more efficiently because of its favored status in credit markets. On the other hand, the federal government issues taxable debt, and thus a federal bank operating with an interest subsidy could disrupt the operation of the tax-exempt state and local bond market. An alternative that would address this concern is a proposal for the federal government to subsidize 25 percent of local debt repayments. In this way the federal government would not compete with the bond market but would encourage people to go into the tax-exempt state and local bond market.

An expanded variation on the bond bank theme is the proposed Reconstruction Finance Corporation—a federal investment and development bank that would lend money to both business and local government for capital investment. Felix Rohatyn (1982) has suggested that, by leveraging an initial federal outlay of $5 billion and $25 billion of government guaranteed bonds, over $60 billion of new investments could be generated. He suggests that Reconstruction Finance Corporation capital would be available only if local agreements on user fees, productivity, and wage concessions ensured the viability of the infrastructure project.

The question that must be asked about such a mechanism is whether a single body should be making such significant investment decisions for both the public and private sectors. Are we ready for mechanisms that move toward the central allocation of credit? Clearly, the nation is moving toward a greater role for state and national government in assisting localities in borrowing for infra-

structure. Some type of state-level bond banks appear to be on the near horizon. Federal bond banks and the Reconstruction Finance Corporation appear more remote.

THE POLITICS OF URBAN PUBLIC WORKS: A NEW ECOLOGY OF GAMES

Political scientist Norton Long viewed politics as an "ecology of games." In the area of public works he saw a particular highway grid as the result of a series of separate games (Long, 1962:142-143):

> A professional highway engineer game with its purposes; a public works department's bureaucracy game; a set of contending politicians seeking to use the highway for political capital, patronage and the like; a banking game concerned with bonds, taxes, and the effects of the highways on real estate; contractors eager to make money on building roads; labor leaders interested in union contracts. . . . Each game is in play in the complicated pulling and hauling of siting and constructing the highway grid.

Today a new set of stakeholders is entering the infrastructure game and their participation will help to shape the outcome.

Public Works as a Job Strategy

In Congress, discussion of public works is inevitably linked to jobs. Various job bills have been introduced based on the premise that public works funding will immediately create thousands of new jobs. In 1982 former Secretary of Transportation Drew Lewis estimated that the gas tax increase would create 58,000 jobs for every $1 billion in spending. It is now clear that his estimate was optimistic, but the true figure is still not clear.

Most studies of the impact of public works spending on jobs indicates that it is not the quickest or most cost-effective way to create employment (Chase Econometrics, 1978). The Bureau of Labor Statistics model estimated only 30,000 jobs per $1 billion for the gas tax or $33,000 per job. Still, discussions of public works will inevitably be linked to jobs, as the debate over the recent Emergency Jobs Bill made clear. In the politics of infrastructure, stakeholders concerned about jobs will influence the outcome of the debate. It is important to examine who has a stake in the politics of infrastructure.

The Business Role in Emerging Political Coalitions

Businesses are among those interested in infrastructure for its own sake, not solely as a job creation strategy. Business clearly cares about the infrastructure it needs for growth and has shown an increasing willingness to pay for it. We can expect to see new and at times unusual coalitions emerging around the issue of infrastructure. Recently, for example, business, local government, and citizen groups came together in California to form a new organization called Californians for Public Improvements; their purpose is to lobby for improvements in infrastructure in the state (J. Lewis Associates, 1982). This group brings together diverse interests that see the need to improve the maintenance of existing infrastructure, establish realistic standards for infrastructure development, and find alternative means for raising additional public capital.

Increasingly, the politics of infrastructure will move toward nontraditional solutions that involve more than government alone. Government fiscal resources are limited, so new methods for financing infrastructure will have to be found. As noted earlier, alternatives involving new types of public-private approaches will be increasingly sought. Alternatives will attract both business, which does not want to see an expansion in government spending, and government leaders, who are looking for new ways of doing business with the private sector.

One cautionary note concerning private-sector involvement in infrastructure is the diversity of viewpoints of different stakeholders. While businesses involved in production and services need and are willing to pay for particular types of infrastructure necessary for their operations, other private businesses may have different interests. The protests of independent truckers against the gas tax and increases in highway user fees dramatize this point. Developers of residential areas may be willing to pay for infrastructure, while "no growth" residents oppose them. Environmentalists and those interested in health will have different views about water quality standards than rate payers and companies eager to avoid investing in costly pollution controls. Thus, not all private interests will line up together on the issue of infrastructure. The questions of what types of infrastructure to create, what the standards will be, and who will pay are all critical in determining the types of particular

political coalitions that are likely to form around a specific in
structure issue. Much of this discussion is likely to redefine
political debate toward structural change.

Structural Changes in Planning and Financing

The politics of infrastructure will push toward structural chan
in financing, not just increases, because business is often m
interested in how the money is spent (and whether the investm
is maintained) than in how much money is spent. More systema
replacement analysis is expected, for example, as well as focu
on maintenance and repair and greater attention to capital b
geting. These outcomes can be expected from the greater invol
ment of business in the infrastructure issue. Harry Hatry of
Urban Institute has outlined a number of ways that business
become more involved in joint public-private condition assessme
and replacement analyses (Hatry, 1981). A business-sponsored
reform group in California, the California Tax Payers Associati
recently organized a statewide conference on new methods for p
serving and maintaining the state's existing public works. Priva
sector involvement in the fiscal crises of New York and Clevela
led to expanded use of capital budgeting techniques. Overall,
new coalitions on infrastructure at the local and state levels
be expected to focus as much on maintenance of what is already
place as on funding for new infrastructure.

One structural change already in progress has critical impli
tions for local government: the emergence of independent auth
ities. George Peterson (1981) of the Urban Institute has found t
"when sewer and water systems are taken out of the general bud
process and entrusted to independent authorities or put on an
terprise fund basis, the capital stock conditions of these syste
are superior; greater attention is given to maintenance; and m
regular capital replacement and repair plans are followed."
emergence of these independent authorities mirrors an earlier
velopment in local government in which independent nonparti
boards and commissions were spun off to operator programs, s
posedly outside politics.

The proliferation of a large number of special authorities can l
to fragmentation of local government and loss of accountabilit
charge made about Baltimore, for example. George Peterson (19

warns that local governments are "unbundling" municipal budgets by earmarking specific revenue sources to finance more narrowly defined public services. He notes that the increased use of dedicated revenue sources and independent authorities could potentially lead to a more fragmented budget process and reduce budget flexibility. A drive to promote the interest of public works that is quite attractive to business could have significant negative effects on the overall operations of local government.

Joint Public-Private Investment

Finally, a potential result of the new forms of public-private collaboration at the local level may well be an increased interest in new ways to negotiate joint public-private investments. In 1979 the Charles F. Kettering Foundation initiated an experiment in local urban policy called the Negotiated Investment Strategy. Mediators helped negotiating teams from local, state, and federal government and the private sector develop agreements on how to invest public and private funds for urban development in three cities: St. Paul, Minnesota; Columbus, Ohio; and Gary, Indiana. An assessment of the experiment by SRI found that each city made significant strides in addressing major intergovernmental and public-private investment issues using the negotiated investment approach (SRI International, 1981b).

An example of how the approach was used is the St. Paul Energy Park. A major industrial/residential/recreational complex on a 250-acre site was negotiated, involving $40 million in public investment and $160 million in private investment over 5 years. Public infrastructure commitments were linked to private commitments in the development.

In Gary, major public infrastructure improvements were linked to private commitments in downtown development and industrial/commercial development adjacent to the municipal airport.

What is different about this approach is that a series of public and private investments were negotiated jointly using a mediator. Thus, trade-offs could be made among government actions (spending or nonspending) and private commitments. While these agreements were experimental in nature, the experience did indicate a new way of negotiating urban investments. The politics of infrastructure with the increased involvement of private business will

push for better methods to relate public works investments to private investment; thus new approaches to negotiating public-private investment at the local level will become increasingly important.

CONCLUSIONS

Ultimately the question of infrastructure boils down to the relative emphasis given to investment versus consumption. Many economists will argue that the 1960s and 1970s were a time of accelerated consumption, both public and private. Consumer spending skyrocketed, services expanded, and public and private savings declined. Both inflation and the ability to deduct interest were incentives to buy now and pay later—personal credit grew and public debt expanded. We were disinvesting in the future. Infrastructure received fewer and fewer investment dollars; when budgets tightened, maintenance was deferred. In all, investment in public works declined 30 percent over the 1970s in real dollars (adjusted for inflation).

Now the bill for deferred maintenance and neglect of new investment that allowed our nation's physical plant to decline is coming due. There is interest in reversing the trend of disinvestment—in investing more in public works. Whether this will occur is related in part to attitudes toward private investment and investment in general.

After all, many other kinds of disinvestment must also be paid for at the same time by both the public and private sectors. The decades-long reluctance of American heavy industry to invest in more modern plants and processes has imposed a cost in unemployment and a lowered tax base in many states. The relative disinvestment in public education over the 1970s imposes a similar cost.

The picture is not all bleak, however. There has been a growing investment in pollution control over the last decade that has a payoff for both public and private sectors. In areas where water pollution control has been vigorously enforced, for example, new industries will have to spend less to obtain clean process water and cities can continue to use existing municipal water supplies.

Individual changes in life-style—investments in smaller cars, energy-saving appliances, shared housing, and recycling—have reduced some of the demand for infrastructure that was foreseen in the early 1970s. Highway systems can be repaired and improved

rather than duplicated. Electricity use is not likely to expand as fast as once thought. Municipal solid waste systems in many areas are likely to change in a variety of ways through the application of new technology.

Given these changes in public and private investment patterns, how do we relate the private investment needs of the 1980s and 1990s to public investment needs? Can both public and private investments be promoted so they can be related to and reinforce each other? By structuring tax policies and other incentives to discourage consumption, perhaps an investment environment could be created that would encourage greater savings to accommodate the needs for both public and private investment. But what price do we pay for doing that?

While the trend toward recognition of the need for greater investment is clear, how the issues will sort themselves out is much less clear. The ways we adapt to technology, find new methods to finance infrastructure, learn to work together, and develop coalitions to encourage investment will determine the future of urban public works.

New and more efficient ways of combining public and private investments are another possibility, but we are only beginning to learn how to do that, and it could take a very long time.

Research Implications

We conclude by outlining a variety of research implications that arise in the areas considered in this chapter.

Technology

1. We need to assess how critical developments in new technology will affect the demand for different types of infrastructure.
2. Key technological innovations in the provision of particular types of infrastructure should be identified.
3. Major impediments to the adoption of technological innovations in infrastructure should be identified to determine what can be done to reduce or remove them.
4. Innovation diffusion networks for public works and what can be done to promote them should be examined, with a special focus on the role of professional associations and career development and training for public works professionals.

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4. Innovation diffusion networks for public works and what can be done to promote them should be examined, with a special focus on the role of professional associations and career development and training for public works professionals.

Economics

1. The equity effect of the movement toward user charges benefit-based methods of financing should be assessed.
2. We should determine how extensively innovative finan alternatives can be used at the local level. Are they of marginal utility or is there a large potential for their us
3. A series of comparative case studies of the effect of de standards on the cost of financing infrastructure shoul prepared.
4. The extent of private-sector participation in infrastructu nancing should be surveyed to help determine the willing of private business to pay for particular types of infrastruc using different financing methods.

Politics

1. Emerging political coalitions for infrastructure should be i tified.
2. The implications of the expansion of independent author and special districts must be analyzed.
3. The experience with joint public-private investment ef should be evaluated.

Long-Range Assessment

1. The effects of life-style changes and changes in busines erations on needs for new infrastructure and public w must be examined.
2. The effects of current government decisions in other fi such as telecommunications, energy, and industrial polic future needs for infrastructure should be assessed.

REFERENCES

Bay Area Council and Association of Bay Area Governments
1983 *Funding Bay Area Capital Improvements and Maintenance.* San Fra Bay Area Council and Association of Bay Area Governments.

Bingham, Richard et al.
1978 Professional Associations as Intermediaries in Transferring Technol City Governments. Report prepared for the National Science Foundat the University of Wisconsin, Milwaukee.

Brown, Lawrence
1982 *Innovation Diffusion: A New Perspective*. New York: Methuen.
Business Week
1981 State and local government in trouble: the decay that threatens economic growth. October 26:136.
California Office of Planning and Research
1982 *Paying the Piper: New Ways to Pay for Public Infrastructure in California*. Sacramento: State of California.
Chase Econometrics
1978 *Evaluation of National Impacts of Local Public Works Programs*. New York: Chase Econometrics.
Chemical Engineering
1983 Road-deicer researchers take the genetic route. May 2:27.
Choate, Pat, and Walters, Susan
1981 *America in Ruins*. Washington, D.C.: Council of State Planning Agencies.
Civil Engineering
1982a The infrastructure problem and the role of the civil engineer. 52(10):42.
1982b Public infrastructure—are more dollars coming? 52(12):63.
Cline, Robert, and Shannon, John
1982 Municipal revenue behavior after Proposition 13. *Intergovernmental Perspective* 8(3).
Goldman Sachs & Co.
1982 Tax Exempt Leveraged Lease Financing for the Public Sector. New York. Unpublished report, Goldman Sachs & Co., New York.
Hatry, Harry
1981 Maintaining the Existing Infrastructure: Current State of the Art and Practice of Local Government Planning. An information bulletin. Prepared for the Urban Consortium by the Urban Institute.
J. Lewis Associates
1982 *California's Crumbling Infrastructure: A Political Strategy*. Sacramento, Calif.: J. Lewis Associates.
Kirlin, John, and Kirlin, Anne
1982 *Public Choices and Private Resources: Financing Capital Infrastructure for California's Growth Through Public-Private Bargaining*. Sacramento: California Tax Foundation.
Kobayashi, Tory
1982 The idea of the technopolis and steps to achieve its development. *MITI Journal* September:2.
Kolderie, Ted
1982 Many Providers, Many Producers: A New View of the Public Service Industry. Minneapolis: The Hubert Humphrey Institute of Public Affairs, University of Minnesota.
Long, Norton E.
1962 *The Polity*. New York: Rand McNally.
Orski, C. Kenneth
1982 Urban transportation. In *Meeting Human Needs: Toward a New Public Philosophy*. Washington, D.C.: The American Enterprise Institute.
Peterson, George
1981 *Financing Options for Urban Infrastructure*. Washington, D.C.: Urban Institute.
1982 *The Allocative, Efficiency, and Equity Effects of a Shift to User Charges and Benefit Based Taxes*. Washington, D.C.: Urban Institute.

Rohatyn, Felix G.
1982 Alternatives to Reaganomics. *New York Times Magazine*, December 1
SRI International
1977a Transportation in America's Future: Potentials for the Next Half Ce Report prepared for U.S. Department of Transportation, Washington,
1977b Infrastructure Linking Science and Technology to State and Local G ment. Report prepared for National Science Foundation.
1980a California Energy Futures: Two Alternative Societal Scenarios and the ergy Implications. Research Report 31 prepared for the California E Commission.
1980b Increasing the Capacity of State Governments to Access and Use Scie Engineering and Technical Resources. Report prepared for the Nation ence Foundation.
1980c Rediscovering Governance: Using Nonservice Approaches to Address borhood Problems. Report prepared for the National Science Foundati
1981a Automated Water Quality Monitoring System Technology Transfer. prepared for National Aeronautics and Space Administration.
1981b Rethinking Urban Governance: An Assessment of the Negotiated Inves Strategy. Report prepared for the U.S. Department of Transportation a U.S. Department of Housing and Urban Development.
1982a Process Development for Production of Calcium Magnesium Acetate (Interim Report. Report prepared for the U.S. Department of Transpor Federal Highway Administration.
1982b Redefining Partnership: Developing Public-Private Approaches to Comm Problem Solving. Report prepared for the U.S. Department of Housi Urban Development.
U.S. Advisory Commission on Intergovernmental Relations
1982 *Significant Features of Fiscal Federalism, 1980-1981*. Washington, D.C Advisory Commission on Intergovernmental Relations.
Vernez, George
1977 Regional Cycles and Employment Effects of Public Works Investment. prepared by the Rand Corporation, Santa Monica, Calif.
Yin, Robert et al.
1976 A Review of Case Studies of Technological Innovation in State and Services. Report prepared by the Rand Corporation for the National S Foundation.

DISCUSSION

John M. Armstrong

The chapter by Henton and Waldhorn provides an excellent mary of the major issues. My remarks focus on the relatio between technology and patterns of urban development and on nological research.

We need a much more complete understanding of this chi or-egg situation. We do not fully understand the extent to v the level or pattern of growth is influenced by the technolo infrastructure. We need to understand the obstacles to using

technology. In particular, there is a need to increase the investment and commitment to specific technological research and development. The payoff should be great in producing tools that can help tackle the degradation of facilities.

As a rule university research has tended to follow the new technologies. Not much research has been done on facilities repair or adaptation of existing technology. Repair technology as a discipline in itself promises to be one of the most challenging aspects of engineering. Interest in the subject has not developed because it is perceived as unglamorous.

There is no distinct line between new construction technology and repair technology. If we allow a rationale for repair as well as replacement, we may develop one of the most challenging aspects of the engineering profession. Otherwise we may have no alternative to a policy of replacing existing systems as they wear out. One of the challenges for the engineering profession is to develop systems by which replacement can occur incrementally.

Innovation will be critical, regardless of the nation's economic fortunes, the use of creative financing, or improvements in the decision process. We cannot afford not to be innovative. The responsibility for innovation ultimately resides with the practicing engineer. For the practitioner to be more innovative, education in engineering must change. In addition to the fundamental training given civil engineers, the professional schools must give more emphasis to the holistic character of infrastructure problems, including system degradation and maintenance. One segment of civil engineering, water resources, has learned to look at large, complex systems. Those lessons could be applied to other branches of the profession.

Engineers also need to be concerned not only with building facility systems well but also with operating them efficiently. Not much attention is given in engineering education to the operation of existing systems, although a few universities now offer programs in engineering administration.

Finally, we need to give considerable research attention to how we go about determining standards for the design and performance of facilities, how we decide what is "safe," and how we measure and quantify information for use by those who make decisions.

Larry J. Feeser

Although the paper deals with technological, economic, and po-

litical issues, my remarks will focus on technology. First, I want t address the direct effects of technology on infrastructure system Some parts of the infrastructure system are basic and are likely t change very little in the near future. Civil engineers will continu to be involved in providing the basic necessities of urban life: she ter, transportation, water, and waste disposal. We will have to fin more effective ways of providing these necessities. I foresee no ama ing technological breakthroughs in most of these systems.

There is some technology on the frontier of change that will u doubtedly affect how we design, build, and operate facilities. Th computer is the most important of these. The technology is movin very rapidly. The replacement cycle is now about 2-3 years, i contrast with a 10-year cycle for most technologies. Computer-aide design and drafting can soon have a direct impact on facilitie systems, as can simulation and operations research.

We must keep in mind that computers are a young industry. Th integrated circuit is only 40 years old. The advances in technolog in the last decade have been so rapid it is no wonder that assim lation of it has been slow in public works agencies. But we ca expect public works applications to blossom rapidly, due in part t necessity and in part due to the dropping costs of computer-aide systems.

Scenarios for the future impact of the computer on the planning design, construction, and operation of urban facilities are not clea just as they are not clear with regard to the effect of the compute on the structure of cities. I doubt that we are really ready for th wired city. The impact, of course, could be startling on where peopl live and work, on how they transact business, and the reasons the come together in urban centers and settlements. The computer a revolutionary technology, so innovation in its use is very hard t predict. Prediction is further complicated by the deregulation communications industries and the entry of communications com panies into computer services and vice versa.

Advances in biotechnology have great potential for waste trea ment. It may become possible to provide clean water and to trea wastes at far lower costs than are necessary today.

Materials research and technological development have consi erable potential, as engineers begin to develop applications for som of the basic scientific research that is under way. Materials researc has been generally underfunded, in part because the lead time f results through practical applications is 10-15 years. Such researc

needs support, however, even though specific results cannot be guaranteed.

Standards for infrastructure can have a tremendous impact on the cost of facilities. We need considerable research on how such standards are set, the kinds of standards that are used, and who is involved in the process. Some standards may be too high, especially in light of the resources that are available to provide facilities. Even though basic materials may cost less today than in the past, the escalation of performance or construction standards may have caused costs to rise considerably.

Regulations need to be reviewed to determine if they pose barriers to innovation. We need mechanisms that target resources but allow considerable flexibility in the technology used to achieve public purposes.

Civil engineers can generate a strong technical basis for the future of cities. Clearly, however, one of the things they need to do is to improve their ability to communicate with nonengineers and to get deeply involved in the process of developing the public consensus on infrastructure policy.

SUMMARY

The Need for Research and Development

Research has been a small item in agencies that are concerned with infrastructure and in the industries that supply the materials and equipment used to build infrastructure. In industry the amount spent on research and development is trivial. For transportation, for example, only 0.017 percent of the total capital expenditure is for research; even this percentage is falling. We cannot rely on the industries involved to do the necessary research. In large part this is because the public procurement process provides no incentives for research so long as the industry standard is met for materials and components. When all infrastructure is counted, an enormous amount of money is involved, but there is little actual research. There is not enough of a critical mass for anything to get done. If we expect to improve the performance or durability of infrastructure, then a sustained research effort is needed.

We should take a hard look at how technology has evolved for each kind of facility system and determine if we can depend on that same process for the future. New advances in facilities technology

may be more complicated than in the past, yet the leverage it c exercise on cost is substantial. If a type of concrete with a 50 perce longer life had been developed, for example, it might have ma unnecessary much of the current concern over the deterioration facilities. We need to deal with the research and development pr lem to make conferences like this one unnecessary 20-30 years fr now.

One of the impediments to the growth of the public budget research and development is that such funds are in the discretiona part of the budget. In addition, lead time for research payoff is lo In seeking federal support for research, it is important to remem that two-thirds of the members of the House of Representati have been elected since 1974 and over half the members have pr ably never been exposed to research processes and facilities.

The Importance of Innovation Transfer

Not only must new technology for and approaches to infrastr ture be invented and developed, but there is also a serious probl in the diffusion and transfer of innovations among public wo agencies and industries. Currently, about half of all new technolo introduced in the United States comes from abroad.

Public works managers are realizing that they will have to innovative to maintain their systems, because there will be l money available to do things the same way as in the past. Th is a lack of knowledge about new technologies that are availab let alone those that are under development. The profession has been creative in setting up leadership mechanisms to get decisi on research and development and innovation transfer made, has it encouraged innovation and the use of new technology. many cases regulations and standards have impaired the use new, feasible technology. Some efforts are being made in such ar as district heating; a program supported by the U.S. Departm of Housing and Urban Development is under way that involves cities.

The "Brain Drain" of Engineers Away from Public Works

With the movement of engineers into the more exotic branc of the profession, such as computers and defense industries, th is considerable concern about where the public works leaders of

future will be found. The American Society of Civil Engineers has found a dramatic drop in civil engineering students and also a decline in the relative quality of students pursuing a civil engineering career. The engineering schools are trying to counter this trend by placing emphasis on some of the more glamorous aspects of civil engineering. There is, however, a real question of whether the trained professionals needed will be available. Further work is needed in the professional schools and elsewhere to give better status to public works careers.

The Impact of the Computer on Cities and Their Needs for Infrastructure

More studies are needed of the impact of the computer on cities and patterns of urban development. Will cities be encouraged to die? Some people seem to be going back to use of the infrastructure of smaller communities. We need, for instance, to obtain some feel for the growth of telecommuting as a substitute for face-to-face contact in work situations. There is some evidence that while remote work locations are attractive for some purposes, people still like to work in proximity to others.

Appendix A
Program

FRIDAY, FEBRUARY 25, 1983

1:00 p.m. WELCOME AND OPENING REMARKS

Martin Lang, Senior Vice President, Camp, Dresser, and McKee, *Symposium Chairman*

George E. Peterson, Director, Public Finance Program, The Urban Institute, *Chairman of the Symposium Steering Committee*

1:30 p.m. THE EVOLUTION OF URBAN PUBLIC FACILITIES SYSTEMS: LESSONS FROM HISTORY

Moderator	Martin Lang, Senior Vice President, Camp, Dresser, and McKee
Paper	Joel A. Tarr, Professor of History of Technology and Urban Affairs, Carnegie-Mellon University
Discussants	Wilfred Owen, Guest Scholar, Brookings Institution Abel Wolman, Consultant, Baltimore, Maryland Randy Hamilton, Dean, School of Public Administration, Golden State University

3:30 p.m. ASSESSING THE NEED: THE STATE OF THE ART

Moderator	John H. Wiedeman, President, American Society of Civil Engineers

	Paper	D. Kelly O'Day, Consulting Engineer, Philadelphia, Pennsylvania, and Lance A. Neumann, Vice President, Cambridge Systematics
	Discussants	Harry Hatry, Principal Research Associate, The Urban Institute Kurt W. Bauer, Executive Director, Southeastern Wisconsin Regional Planning Commission
7:00 p.m.	Dinner	

SATURDAY, FEBRUARY 26, 1983

9:00 a.m. THE ECONOMICS AND FINANCING OF URBAN PUBLIC FACILITIES

Moderator	Thomas H. Neilson, Acting President, The Irvine Company
Paper	George E. Peterson, Director, Public Finance Program, The Urban Institute
Discussants	Franklin D. Raines, Vice President, Lazard Freres, New York City Forest (Tim) Witsman, County Administrator, Sedgewick County, Kansas

11:00 a.m. THE POLITICS OF URBAN PUBLIC WORKS DECISIONS

Moderator	Stuart C. Sloame, Deputy Assistant Secretary for Community Planning and Development, U.S. Department of Housing and Urban Development

	Paper	Heywood T. Sanders, Professor of Urban Studies, Trinity University
	Discussants	Philip Dearborne, Vice President, Greater Washington Research Center Scott Johnson, City Manager, Oklahoma City, Oklahoma Henry Gardiner, City Manager, Oakland, California
1:00 p.m.	Lunch	
2:00 p.m.	THE FUTURE OF URBAN PUBLIC FACILITIES	
	Moderator	The Honorable Bob Edgar, U.S. House of Representatives
	Paper	Douglas G. Henton, Senior Policy Analyst, and Steven A. Waldhorn, Department Director, Policy Development, SRI International
	Discussants	John M. Armstrong, Professor of Civil Engineering, University of Michigan, Ann Arbor Larry J. Feeser, Associate Dean of Engineering, Rensselaer Polytechnic Institute
4:00 p.m.	SUMMARY SESSION: CRITICAL RESEARCH AND POLICY ISSUES	
	Comments by the panel moderators, rapporteurs, and symposium chairman	

Appendix B
Participants

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